POWER PLANT ENGINEERING

Established Over 29 Years

VOL. XXIX CHICAGO, MAY 15, 1925 No. 10

Contents of this Issue

Page

Additional Power for the Tri-Cities. Illustrated.....516
Factors Governing the Storage of Coal.....523
Extraction Engines for Industrial Power Plants. By F. Johnstone-Taylor. Illustrated 525
Stoker Operation Improved by Simple Changes. Illustrated.529
Distilled Feed Water Helps Boiler Equipment. Illustrated .. 531
Tests of CO_2 Recorders. By J. F. Barkley. Illustrated.....533
Unit System of Pulverizing Coal Applied to Boilers. By Henry B. Jones.....534
Diesel Engine Overall Economy. By C. B. Jahnke. Illustrated 535
Measurement of Coefficients of Viscosity.....540
Operation of Converting Apparatus—IX. By V. E. Johnson. Illustrated 541
Automatic Control for Substation Apparatus. Illustrated..543
Old Station Grows to Large Proportions. By W. R. McCann. Illustrated 546
Distance Between Shaft Centers. By W. F. Schaphorst.....548
Training Course Develops Power Plant Personnel. By H. A. Frommelt 549
The First Link in the Evolution of Chain Drive.....550
Right Conditions Aid Hydro-Electric Operation. By Charles B. Hawley 551
Power Plant Development in the Orient. By W. C. Heckerath 554
Fuel Conservation Urged by Chamber of Commerce.....554
Letters Direct from the Plant: Heat Loss in Flue Gases. Handling Workmen Under Varying Conditions. Simple Chart Shows Proper Piston Ring Dimensions. Emergency Gaskets of Building Paper and Sheet Rubber. Auxiliary Safety Valve Acts as Signal. Steam Meters Save $6000 a Year. Disabled Valve Held Shut by Machinists' Clamp. Washers Keep Packing out of Pump Cylinder. Illustrated.555
Questions and Answers: Oil and Grease Extraction from Exhaust Steam. Corliss Engine Pounds After Being Overhauled. Figuring Air Compressor Speed. Cinder Seal Under Chain Grate Stokers Necessary. Illustrated..558
Condensate from the World's Power Plant. By William Sibley 560
Editorial Comment: Midwest Power Show Fills a Need. Success Through Enthusiasm. Power Plant Apprentices..562
Off Duty 563
General Electric Develops New Synchronous Motor. Illustrated 564
New Seatless Balanced Blowoff Valve. Illustrated.....564
Midwest Engineering Exposition to Be Held in Chicago.....565
Imita-Gold, a New Alloy.....565
Portable Electric Welder. Illustrated.....565
Ball Bearing Spur Gear Reducer. Illustrated.....566
Improvements to V-Notch Meter. Illustrated.....566
Francis Hodgkinson Presented with Cresson Medal.....567
News Notes 568
Catalog Notes 568

Published on the 1st and 15th of each Month by the
Technical Publishing Co., 537 So. Dearborn Street, Chicago
New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1925, by Technical Publishing Co.

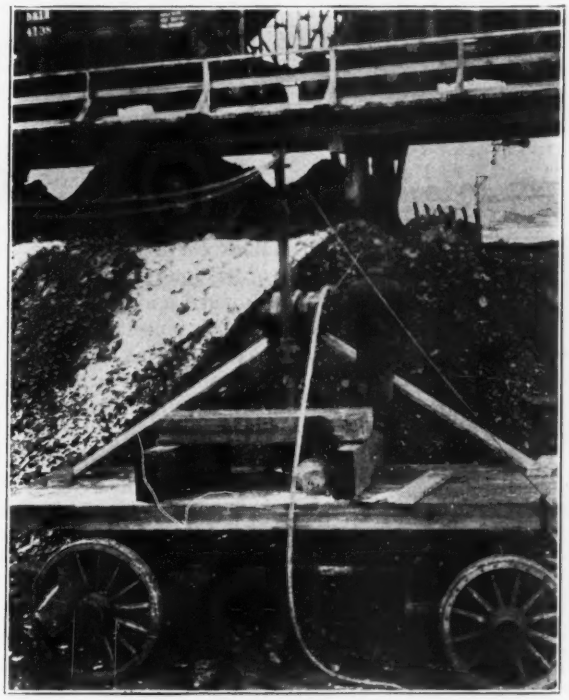
Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue 23,850

EDITORIAL STAFF

ARTHUR L. RICE, Editor
R. E. TURNER, Managing Editor
A. W. KRAMER, Associate Editor
ROGERS A. FISKE, Associate Editor
CHESTER R. EARLE, Associate Editor
JOSEPH R. DARNELL, Associate Editor



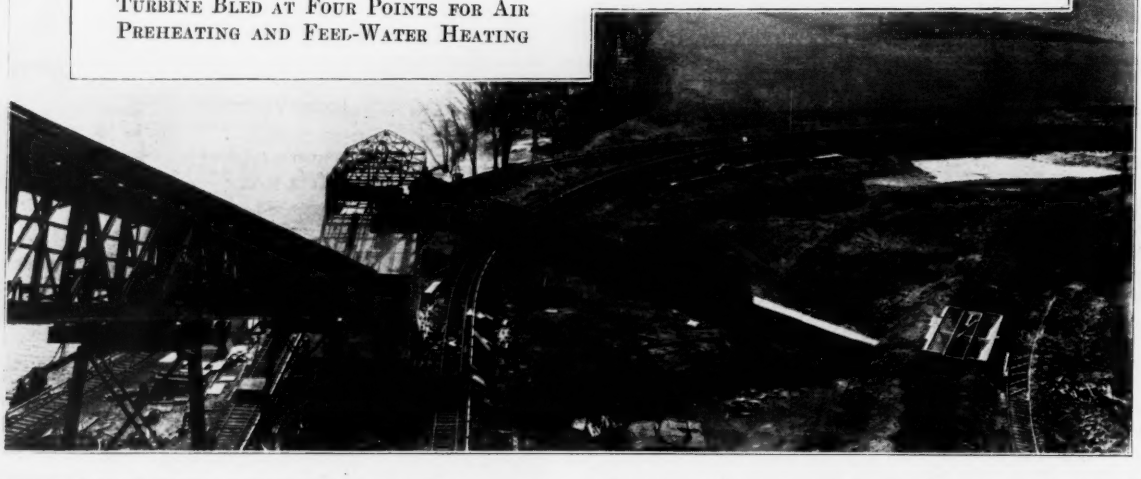
Storing Steam

IT MIGHT be said that it is highly impractical to store steam. That is no doubt true, but why not store those essentials which are necessary for the production of steam? Some wise operators recognize this and are buying coal at a saving and storing it against the day when uncontrollable factors may come into play which will interfere with the effective productiveness of the invested dollar. At the same time there are those who are not so alert and who are working a hardship not only upon themselves but also upon all the users of fuel. The effects of a concerted movement of coal storage will be cumulative. The greatest benefits will be derived when the majority put it into practice. This problem is outlined in the second article of this issue.

REDUCING VALVES as prime movers? Yes, they are often used in industrial plants, in the form of bleeder turbines and extraction engines from which low-pressure steam is taken for process work. Interesting data on European types of these extraction engines appear on page 525.

Additional Power for the Tri-Cities

Turbine Bled at Four Points for Air Preheating and Feel-Water Heating



EARLY THIS SUMMER there will be put in operation near Davenport, Iowa, the new Riverside station of the United Light & Power Co. This plant is well located, since it serves the great industrial district comprising the tri-cities of Davenport, Rock Island and Moline, the latter being the home of the famous John Deere farm implement manufacturing company.

Riverside plant is located about 5 mi. up the Mississippi River from Davenport. It is across the river from Rock Island and Moline and, therefore, on the same side of the river with Davenport. To reach the Illinois side of the river it is necessary to span the river with six cables each 1800 ft. long. The voltage rating of the generator is 13,200 and this is to be stepped up to 66,000 v. for transmission to the opposite side of the river. Several miles down the river from this plant is the United States Government Rock Island Arsenal. It is located on an island in the river and, therefore, by crossing the river at the island the maximum span has been kept down to 1800 ft. This line leaves the outdoor substation at the plant and follows along the right of way of the traction company to a point opposite the island. The construction of this part of the line is interesting in that it is carried on steel towers which at many points straddle the tracks and trolley construction of the traction company.

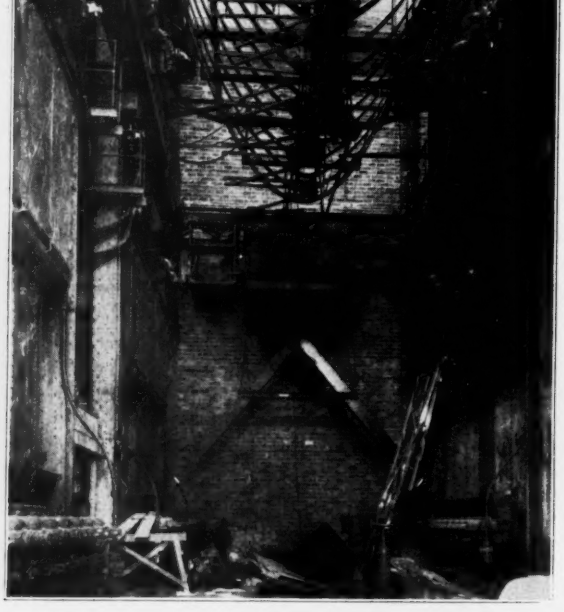


FIG. 1. FEEDWATER PIPING CAN BE SEEN ON EITHER SIDE OF THE COAL BUNKER SKELETON

At the point where the line spans the river two 200-ft. steel towers have been erected, one on the river bank and one on the island. The cables which will be used consist of a stranded galvanized-steel core around which are stranded the aluminum conductor wires. The steel core is used to give the necessary strength required for a span of that distance.

It is contemplated now that coal from the central Illinois field will be burned. Under ordinary conditions, this coal will be delivered by steam railroads to the Rock Island terminal. From that point to the plant the cars will be handled by the traction company, which is controlled by the United Light & Power Co. All switching at the Riverside station will be done by an electric locomotive which operates on the third-rail system. Coal will be stored and reclaimed by means of a steam-driven locomotive crane.

Separate Structure Houses the Bradford Breaker

Coal for immediate use will be unloaded from hopper bottom cars into a concrete track hopper from which a feeder will deliver it to an inclined belt conveyor that terminates in a separate structure which houses a Bradford breaker, the capacity of which is 250 T. per hr. From the breaker the coal is delivered by another inclined belt conveyor to the west end of the boiler house at a height so that it will discharge on a distributing conveyor which

unloads at any point over the suspended coal bunker above the boilers.

Distribution of coal to the stoker hoppers is accomplished by means of a 10-T. weigh larry which is controlled from a cab. All the conveying equipment was furnished by the Brown Hoisting Machinery Co. The belt conveyors which are 36 in. wide have a rated capacity of from 60 to 250 T. per hr. The coal bunker, which was also furnished by the Brown Hoisting Machinery Co., and is of Ferroinclave construction, has a storage capacity of 924 T. The Brown, 15-T. locomotive crane is rated at 100 T. per hr. and the yard storage is estimated at 60,000 T.

Each boiler is served by a reinforced-concrete ash hopper, which is designed with a flat bottom. This arrangement gives an ash storage capacity of 1175 cu. ft. per boiler. Each hopper is equipped with three 4 by 4-ft. hydraulically-operated ash gates made by the Baker Dunbar Co. These gates operate in the horizontal plane and are so designed that the quenching water will be drained off to the sewer. Standard railroad cars will be switched directly under the hoppers by the third-rail locomotive. For some time to come the ash can be used to fill in low ground.

Economizers Reduced the Size of Boilers

Four boiler units are required to serve the first turbo-alternator, which is rated at 25,000 kv.a. These are placed so that two of them are on each side of the firing aisle, arrangements having been made so that the weigh larry feeds to both sides of the firing aisle. These boilers are of the Heine cross-drum type and each contains 10,438 sq. ft. of heating surface. During the early stages of design it was contemplated to use boilers of a higher rating, but without economizers. The final arrangement, however, consists of boilers of the size mentioned and Foster economizers which contain about 62 per cent as much heating surface as there is in the boilers.

It was also contemplated at first to use boilers operating at 375 lb. pressure, thus allowing about 350 lb. pressure at the turbine. An investigation revealed that a substantial saving could be made in the water rate of the turbine if the steam pressure was increased. The final arrangement resulted in a boiler pressure of 425 lb. and a pressure at the throttle of 400 lb. The total temperature of the steam will be approximately 700 deg. F.

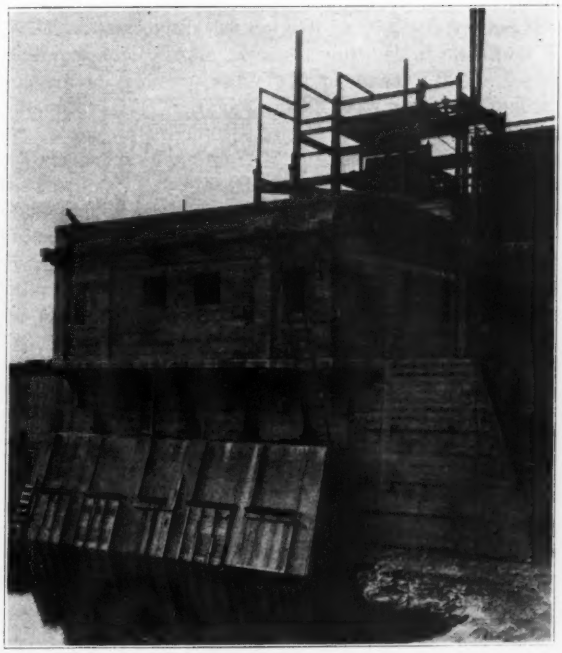


FIG. 2. SCREEN HOUSE. VIEW TAKEN BEFORE THE COFFER DAM WAS OPENED. WOODEN GATES ARE TEMPORARY

One difficulty in the operation of superheated steam plants has come about, due to the fact that neither convection nor radiant heat types of superheaters afford a flat curve over the full range of operation. The characteristic of the one type is opposite to that of the other, therefore, by installing both types in the same setting a flat curve or practically constant superheat can be obtained over the full range of boiler operation. With this in mind both types of superheaters have been used in this installation. The convection superheater, made by the Power Specialty

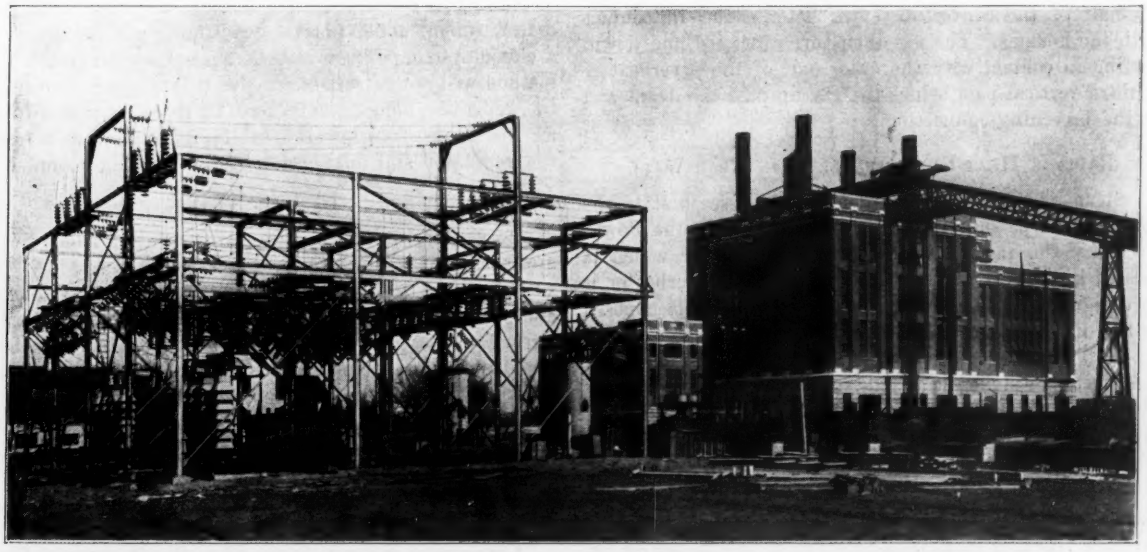


FIG. 3. SWITCH HOUSE IS LOCATED BETWEEN THE MAIN BUILDING AND THE OUTDOOR SUBSTATION

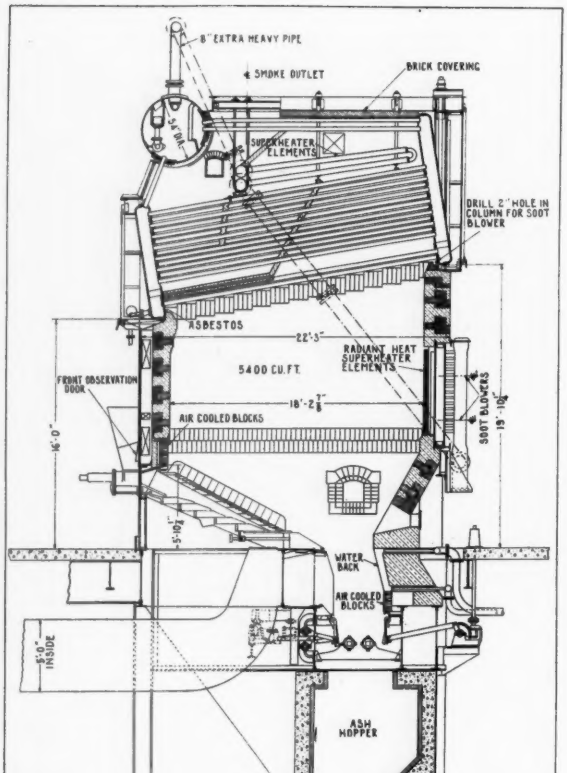


FIG. 4. FURNACE AND BOILER EQUIPMENT INCLUDES A WATER BACK AND BOTH CONVECTION AND RADIANT HEAT SUPERHEATERS

Co., contains 2925 sq. ft. of heating surface and it is located directly above the tube nest which connects the two boiler headers. Horizontal baffles, laid on the second row of tubes, extend from the front header back for about 40 per cent of the depth of the furnace. From the end of this baffle a vertical baffle extends up so that approximately one-half of the convection superheater comes in contact with the hot gas. The gas then turns forward and down, coming in contact with the other half of the superheater. A third vertical pass brings the gas up past the drum and to the breeching connection.

Radiant Heat Superheater Is in Rear Wall

Steam is taken from the drum and passes first to the convection type superheater. It then passes to the Power Specialty Co. radiant heat type of superheater which is located in the rear wall of the setting. This superheater is so designed that 89 sq. ft. of heating surface is exposed to the direct heat of the furnace. It stands about 5 ft. 6 in. high and the lowest element is about 2 ft. above the top line of the stoker bed. This superheater consists of 3 by 1½-in. cast-steel, Foster, radiant-heat superheater elements which are connected by 2-in., No. 11 ga. tubes to 15-in. headers located outside of the rear wall.

Each boiler will be fired by a 10-retort, 33-tuyere, Taylor stoker which will be hydraulically driven, the oil pressure reaching at times a pressure of 700 lb. per sq. in. The projected grate area of each stoker is 270 sq. ft., giving a ratio between heating surface and grate area of 38.7 to 1. The stokers are set under what is nominally considered the rear of the boiler, that is, under the lower header. The low header is about 16 ft. above the floor line and the other header is about 19 ft. 10 in. above the floor line.

Each stoker is equipped with an hydraulically-operated clinker grinder. Opposite the lower end of the stoker is a high pressure water back which is connected to the boiler drum. Air-cooled blocks are used in the front wall just above the stoker. The side walls are of brick and are encased in steel so that air may be drawn down between the outside of the wall and the steel casing. This air passageway is open at the top where dampers are provided. The air will pass downward along the wall and discharge into the fan room directly below. This fan room can be closed so that as the air is removed by the blast fans fresh and preheated air will enter the room after having passed along the furnace walls. It is estimated that the air for the furnaces will be heated in this way to about 130 deg. F.

The forced blast fan room is located directly below the firing aisle and between the two ash tracks. Four Green Fuel Economizer Co. double inlet, radial flow units have been installed, one being driven by a steam turbine and the other three by a dual motor drive which consists of a 25-hp. slip ring motor on one end of each fan and a 100-hp. slip ring motor on the opposite end. This arrangement of dual drive was not decided upon until a thorough investigation had been made of the brush-shifting motor. It was found that the dual drive was as efficient if not more so than the brush-shifting motor, except at the peak load operation of the boiler. Over that range capacity is more important than is economy. Further, the dual drive afforded a better assurance of continuity of service and it could be installed at a considerable saving over the cost of the brush-shifting motors.

Each of these fans is rated to give 6 in. static pressure and 67,000 cu. ft. of air per min. As previously explained, these fans take air directly from the fan room. One fan is now equipped with a fin-type air heater so that surplus low pressure steam can be used to preheat the air further. If this arrangement proves satisfactory, the same type of heaters may be installed on the other fans.

One other probable source of warm air is from the generator, which, under normal conditions, will be cooled by a closed system. There may be times, however, when this method will not be satisfactory, so it is planned to connect the generator housing with the fan room by means of an air duct, thus drawing air from the turbine room through the generator and discharging it into the fan room.

Induced Draft Fans Are Used

Foster economizers of 6420 sq. ft. heating surface each are located on a platform directly above the boilers. The gas from each boiler passes upward through an economizer and then down through a return bend connection to the Green induced draft fan. Four of these fans have been installed, each of which is rated at 8 in. static pressure and 93,000 cu. ft. of gas per min. They are arranged for dual drive by means of one 40-hp. and one 165-hp. slip ring induction motor on each fan. Each boiler is served by a guyed steel stack which rests directly on the induced draft fan housing. These stacks are unlined and are 50 ft. high by 6 ft. 6 in. in diameter.

Condensing water is taken from the Mississippi River through a screen house which was constructed of reinforced

concrete. The channel of the river at this point is cut in rock and the current is comparatively swift so that little trouble will be experienced from silt. It is also expected that ice troubles will not be serious. Stationary screens are provided at the intake to the screen house. These are arranged so that they may be removed for cleaning or replacement by means of a block and tackle secured to I-beams which were placed for that purpose. Inside the screen house are two traveling screens. The intake tunnel extends to a point directly under the two motor-driven circulating pumps. The discharge from the top of the condenser drops down to the discharge tunnel which discharges into the bay between the screen house and the main building.

One circulating pump is rated at 21,000 gal. per min. With one pump operating and water at 80 deg. F., or less, a vacuum of 28 in. will be maintained. The combined capacity of the two pumps is 32,000 gal. per min. Twenty per cent speed variation in eight steps is provided on the 150-hp. slip ring induction motors which drive these units. The two Radojet air pumps are provided with inter and after coolers. The condensate removal units are in duplicate and have a capacity of 600 gal. per min. against a head of 180 ft.

Two Sources of Service Water Supply

Water for general house service is obtained through two lines which tap into the intake tunnel, one 700-gal. and two 300-gal. pumps having been installed for this service. An auxiliary supply of water is obtained from a flowing artesian well, which will be pumped by a motor-driven plunger pump, the water being discharged into an overhead tank of 15,000 gal. capacity. The overflow from this tank will flow through two check valves to the service water line from the house service pumps.

All water for the boilers will be purified by means of an evaporator. Under normal conditions of operation the per cent of make-up water will be small. Water for the evaporator will be taken under float control from the service line which may furnish all river water or a mixture of river and well water at such times as the tank may be overflowing. The make-up water first passes through the oil coolers, thus gaining some heat. From the evaporator it passes to the third stage heater, the condensed vapor returning finally to the hot well under the condenser. All boiler water is thus gathered at the condenser hot well and forced by the hot well pumps through the fourth and third stage heaters. Here the boiler feed pumps pick up the water and force it through the economizer and the first stage heater which is supplied with steam at 358 deg. F. at a pressure of 149 lb. absolute.

The temperature range is as follows: drains to hot well, 146 deg. F.; water from hot well, 101 deg. F.; after fourth stage heater, 141 deg. F.; after third stage heater, 205 deg. F.; after the economizer, 298 deg. F. and after the first stage heater the feed water has a temperature of 351 deg. F.

Pure Water Stored in Concrete Tank

Floating on the boiler feed line is a surge tank. Another interesting feature of this installation is the pure water tank which is constructed of reinforced concrete and is located beneath the fan room floor and one of the ash car tracks. This tank provides a storage space for all excess pure water which is not circulating in the boiler feed system. Many of the low pressure drips return to it and if a boiler is to be drained the water will be run to this tank and stored until it comes time to fill the boiler again.

Three Allis-Chalmers boiler feed pumps have been provided, one being turbine driven and two motor driven. The turbine drive is a Terry on a 500-gal. per min. pump. A 200-hp. Allis-Chalmers motor drives a 300-gal. pump and a 300-hp. Allis-Chalmers motor drives a 500-gal. pump.

One extremely interesting feature of the feed water system is that of the piping in the boiler room. This piping is located above the boiler drums and between the

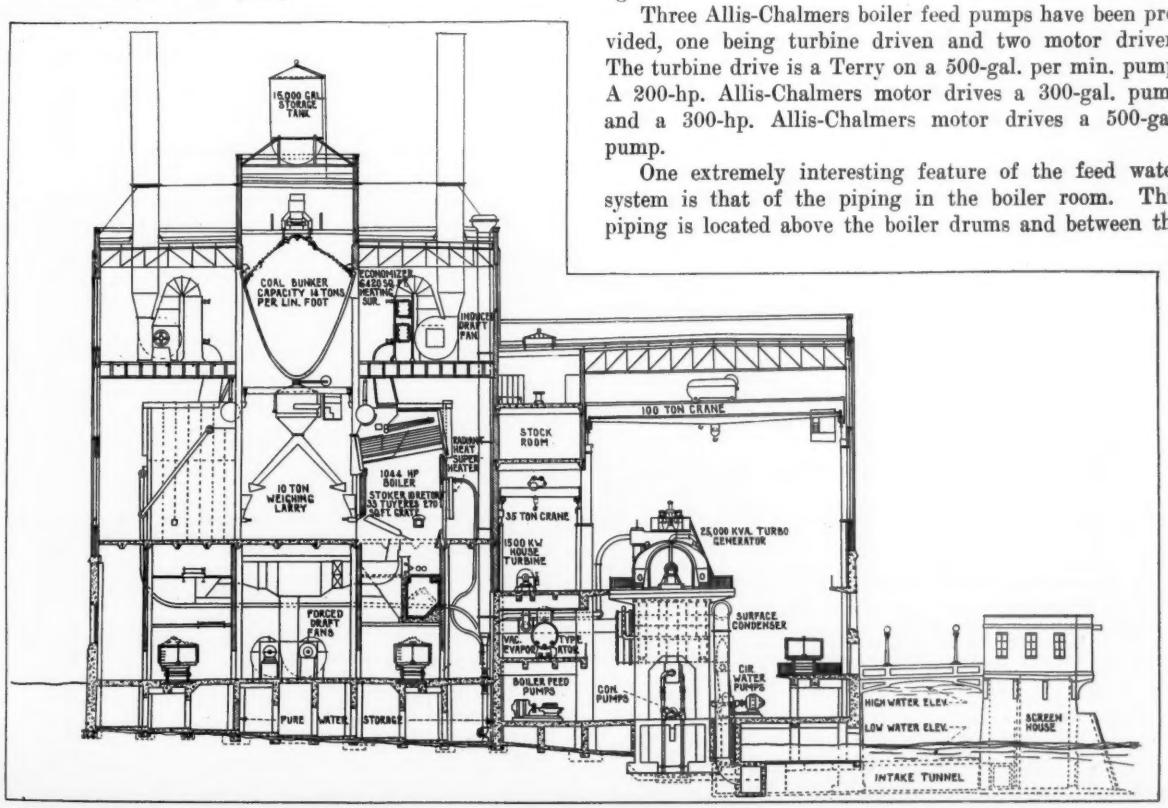


FIG. 5. STEEL, UNLINED STACKS ARE SUPPORTED DIRECTLY ON THE INDUCED DRAFT FAN HOUSINGS

Summary of Principal Equipment at the Riverside Station

Ash Handling Equipment—
- Gates, manufacturer....Baker Dunbar Co.
- No. per boiler....3
- Size....4 ft. by 4 ft.
- Operated....Hydraulically

Boiler Feed Pumps—
- Manufacturer....Allis-Chalmers Mfg. Co.
- Number installed....3
- Type....8 stage, 525 lb. pres.
- Capacity, gal. per min....1—300 and 2—500
- Drive....2 motor-driven, 1 turbine-driven

House Service Pumps—
- Manufacturer....Allis-Chalmers Mfg. Co.
- Number....3
- Type....Single stage
- Capacity, g.p.m....1—700, 2—300
- Drive....Induction motors

Miscellaneous Equipment—
- Steam valves....Lunkenheimer Co. and Crane Co.
- Stop and check valves....Schutte & Koerting Co.
- Blowoff valves....Yarnall-Waring Co.
- Safely valves....Manning, Maxwell & Moore, Inc.
- Atmospheric relief valves....G. M. Davis Regulator Co.
- Air cooler....Griscom-Russell Co.
- Screens, revolving....Chain Belt Co.
- Air compressor....Ingersoll-Rand Co.
- Electric cranes....Whiting Corp.
- Sootblowers....Diamond Power Specialty Corp.
- Steam separators....Griscom-Russell Co.
- Oil filter....S. F. Bowser & Co., Inc.
- Water columns....Reliance Gauge Column Co.
- Differential pressure regulators....D. H. Skeen & Co.
- Feed water regulators....Northern Equipment Co.

Main Generating Unit—
- Manufacturer....Westinghouse E. & M. Co.
- Type....Single cylinder, bleeder, condensing
- Capacity, kv.a....25,000
- Speed, r.p.m....1800
- Superheat, deg. F....250
- Steam pressure, lb. ga....400
- Generator voltage....13,200
- Phase....3
- Cycles....60
- Cooling air, cu. ft. per min....65,000

Exciters—
- Manufacturer....Westinghouse E. & M. Co.
- One 110-kw. direct-connected and one 200-kw. motor-driven.
- Voltage....250

House Turbine—
- Manufacturer....Westinghouse E. & M. Co.
- Rating....1500 kw., 480 v., 3 ph., 60 cycles

Electrical Equipment—
- Main switchboard....General Electric Co.
- Transformers....General Electric Co.
- Oil circuit breakers....Westinghouse E. & M. Co.
- House service board....Westinghouse E. & M. Co.

Condenser and Auxiliaries—
- Manufacturer....C. H. Wheeler Mfg. Co.
- Type....Surface, 2 pass
- Tubes....1 in., No. 18 ga.
- Surface, sq. ft....30,000
- Supported on....Spring bases
- Connection to turbine....Rigid
- Circulating pumps, No....2
- Size, in....24
- Capacity each, g.p.m....21,000
- Capacity combined, g.p.m....32,000
- Drive....150-hp. slip ring motors
- Speed variation, per cent....20
- Expansion joints....U. S. Rubber Co.
- Condensate pumps, No....2
- Size, in....5
- Capacity, g.p.m....600
- Head, ft....180
- Driven by....50-hp. squirrel cage motors
- Air pumps....Radojet
- Inter and after-coolers....Yes

Evaporators—
- Manufacturer....Griscom-Russell Co.
- Type....High pressure, single effect
- Capacity, lb. per hr. (normal)....6075

Heaters—
- Manufacturer....Griscom-Russell Co.
- Number....3
- Type....Closed
- Capacity each, lb. per hr....240,000

Boilers—
- Manufacturer....Heine Boiler Co.
- Number installed....4
- Type....Cross drum
- Heating surface, each, sq. ft....10,438
- Tube arrangement....15 high, 33 wide
- Operating pressure, lb. ga....425
- Ratio, heating surface to projected grate area..38.7 to 1
- Furnace vol. cu. ft....5400
- Sq. ft. heating surface per cu. ft. furnace....1.93
- Cu. ft. furnace per sq. ft. projected grate area....20

Superheaters—
- Manufacturer....Power Specialty Co.
- Type....Convection and Radiant
- Superheat, deg. F....250
- Surface, convection superheater sq. ft....2925
- Surface, radiant heat superheater sq. ft....89
- Ratio, radiant to convection surface....1 to 33

Economizers—
- Manufacturer....Power Specialty Co.
- Type....Foster
- No. installed....4
- Surface, sq. ft. each....6480
- Cleaned by...Diamond soot blowers and water flushing

Stokers—
- Manufacturer....American Engineering Co.
- Number per boiler....1
- Type....Taylor, underfeed
- Size....10-retort, 33-tuyere
- Projected grate area, sq. ft....270
- Drive....Hele-Shaw, hydraulic

Forced Draft Fans—
- Manufacturer....Green Fuel Economizer Co.
- No. installed....4
- Type and size....Double inlet, 54 in.
- Capacity, cu. ft. per min. each....67,000
- Static pressure, in....6
- Drive....Three dual motor and one turbine

Induced Draft Fans—
- Manufacturer....Green Fuel Economizer Co.
- No. installed....4
- Type....Steel plate, 84 in.
- Capacity, cu. ft. per min., each....93,000
- Static pressure, in....8
- Drive....Dual, slip ring induction motors

Stacks—
- Made by....Cullen Co.
- No. installed....4
- Support....On fan housing
- Diameter, ft....6.5
- Height, ft....50
- Type....Steel, guyed, unlined

Coal Handling Equipment—
- Furnished by....Brown Hoisting Machinery Co.
- Belt conveyor capacity, T. per hr....60 to 250
- Weigh larry, T. capacity....10
- Ferroinclave bunker, T. capacity....924
- 15 T. locomotive crane, T. per hr....100
- Yard storage, T....60,000
- Bradford breaker, T. per hr....250

building columns and the coal bunker. It is installed on the loop system in which there are three complete loops around the center portion of the boiler room. Three risers extend from the boiler feed pumps in the basement to the upper of the three loops. It is from this loop that the water passes to the economizers. After having passed through the economizers the water returns to the lower loop, then to the first stage heaters and from there to the third or center loop to which connections are made to both ends of each boiler drum. The advantage of this layout is at once apparent because it gives extreme flexibility in the isolation of any one or more of the boilers or auxiliary units. It is further of a great advantage in that this type of design assures continuity of operation.

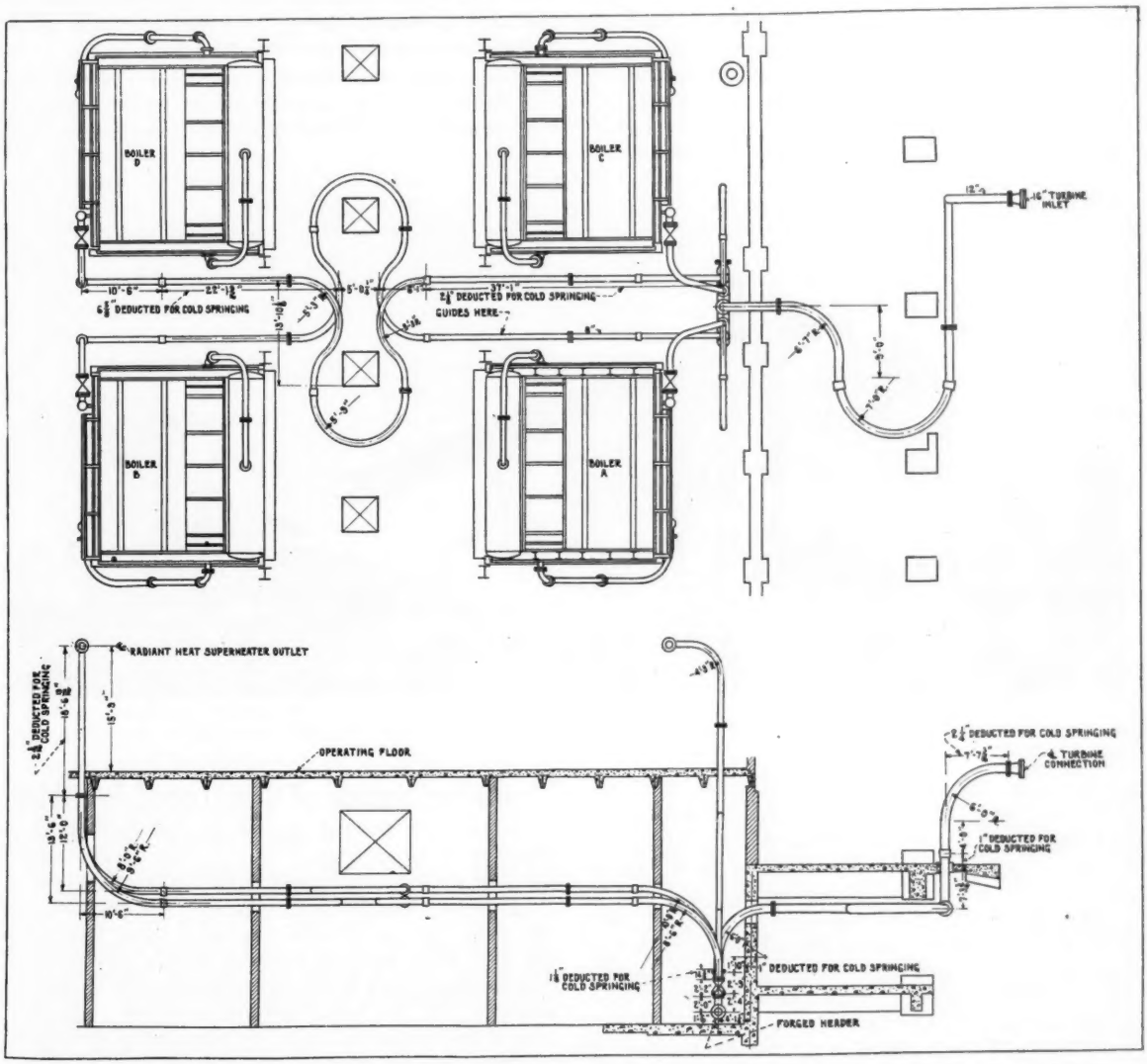


FIG. 6. BOILER AND TURBINE LEADS ALL COME TO A FORGED HEATER WHICH IS ANCHORED TO THE FLOOR

Initial Unit Rated at 25,000 kv.a.

For the present there will be but one turbo-generator installed. This is a Westinghouse unit rated at 25,000 kv.a., 3 phase, 60 cycles, 13,200 v. and 1800 r.p.m. The steam pressure at the throttle will be 400 lb. ga. and the superheat will be 250 deg. F. When this unit is operating condensing with 1-in. back pressure it will have a water rate of approximately 9.5 lb. at its most economical load which is about 16,000 kw. One exciter is direct connected and rated at 110 kw. and 250 v.

All auxiliaries throughout this plant are driven by 440-v., a.c. motors. Current for their operation may be taken from the main bus bars through 2000-kv.a. transformers. The auxiliary bus consists of two sections and the auxiliaries are so grouped in duplicate that some of the motors for each class of service will draw power from their respective section of the bus. This arrangement assures continuity of service.

One 1500-kw. house turbine has been installed, which will float on the line as a synchronous condenser when the main unit is up to speed. When operating in this manner a vacuum is kept on the turbine casing, thus avoiding the use of steam for cooling. This house unit is rated at 1875 kv.a., 80 per cent power factor, 480 v., 3 phase and 60 cycles. There is also an m-g exciter set consisting of a 300-hp., 440 v., 1170-r.p.m. a.c. motor direct connected to a 200-kw., 250-v. d.c. generator which is used for excitation purposes.

The switchhouse, a three-story building, is located just to the north of the main structure. In it are housed the 13,200-v. bus structure and the main control board.

Boiler Leads Made of Tubing

High-pressure steam piping was furnished by the Midwest Piping & Supply Co. The boiler leads are ½-in. tubing and the 12-in. pipe is ⅝ in. thick, lap-welded. The 6-in. boiler feed lines are of extra heavy, lap-welded pipe. Steam pipe joints are of the Fantz type which are made up without a gasket, the two pipe ends meeting in a metal to metal joint. These joints are made by grinding spherical faces on the pipe and the flanges swivel on the pipe. This construction permits the flanges to adjust themselves to a slight deflection in the line.

At a temperature of 700 deg. F. extreme care must be taken to avoid stresses in the pipe lines, and further, a definite limit was placed by the turbine builder upon the thrust which would be allowed by the pipe against the turbine steam chest. These problems had to be met by designing the steam piping with sufficient bends to take up the stress resulting from the expansion of the pipe. Each boiler lead, from the two boilers located at the north wall, leaves the radiant heat superheaters and drops straight down through the operating floor. There it makes a quarter bend and then runs horizontally for a short distance to a double off-set U-bend placed in the horizontal plane. It then continues to the rear of the boilers near the turbine room and drops down through a quarter bend to a special forged header which is anchored to the basement floor.

Five Connections Can Be Made to Header

This fitting or header has five welded nozzles, the four outside nozzles being used for connection to the boiler leads and the center nozzle being used for the turbine lead. One end of this header is blanked off for future connection and the opposite end is provided with a nozzle for the auxiliary steam line. Leads from the boilers near the turbine room are each fitted with a quarter bend and an expansion U-bend. Both the turbine lead and the boiler leads connect to the header in the vertical plane.

The condenser is bolted directly to the turbine casing and is supported on a spring base. Rubber expansion joints are placed on each side of the circulating pumps and a fifth rubber expansion joint is placed in the water discharge line from the condenser.

The building is constructed of reinforced concrete, steel and brick, the roof being of a poured-gypsum slab. The generator room is served by a Whiting 100-T. crane, which is also equipped with a 25-T. auxiliary hook. The house turbine is served by a 35-T. electric traveling crane which is operated from the floor. An electric elevator operates between the basement and the upper floors.

Design and construction of the entire station, including the building, is being carried on by the engineering department of the United Light & Power Engineering & Construction Co.

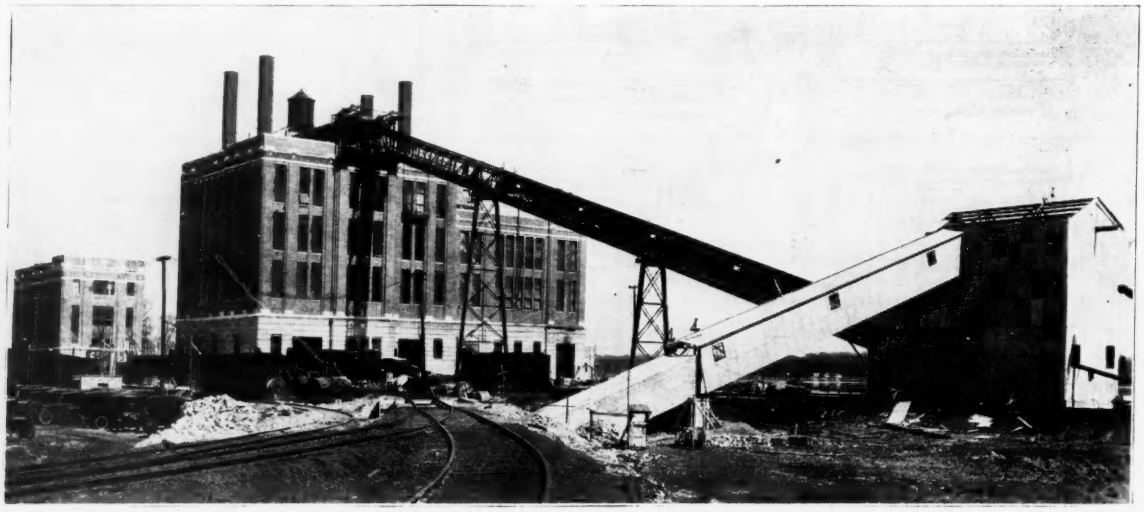


FIG. 7. COAL BREAKER IS HOUSED IN A SEPARATE STRUCTURE LOCATED BETWEEN THE TWO BELT CONVEYOR RUNS

Transformation of Coal Into Liquid Fuel

In Recherches et Inventions for September, M. Muraour gives an account of the experiments made in the attempts to produce a new liquid fuel at the Kaiser Wilhelm Institut fur Kohlenforschung. Although no striking results have as yet been attained, a liquid fuel containing 3968 B.t.u. has been produced from a quantity of coal representing 11,904 B.t.u.; the remainder, not without considerable loss, has been recovered as a gas. The coal is treated first by distillation at low temperature, giving liquid and semi-coke compounds. The coke is then used for the manufacture of water-gas and finally the water-gas is transformed into liquid fuel by passage at high pressure over a catalyser, an operation in which the catalyser may be iron and carbonate of potassium or of rubidium.

Glare, says the report of the Eyesight Conservation Council, is one of the most insidious causes of eyestrain and is "unquestionably the most prevalent and objectionable concomitant of improper lighting." Science has revealed three chief sources of glare—excessive brightness, excessive volume of light and excessive contrast. Excessive brightness of light sources is, the Council's report says, now believed to be the worst offender.

Factors Governing the Storage of Coal

BENEFITS TO BE DERIVED FROM COAL STORAGE DEPEND UPON THE INITIATIVE IN THE MOVEMENT BEING TAKEN BY THE PURCHASER

INDUSTRY IN general and power plants in particular are subject to serious interruptions and therefore losses due to more or less crude methods of mining, distributing and storing coal. At first thought, it might seem that the ultimate consumer could play no part in the economic effect which purchasing may have upon mining and distribution. This, however, is not the case, for the direct result of haphazard buying on the part of the public has resulted in the mines working part time, thus necessitating a mine capacity just about double that which would be required if they were called upon to meet a fairly uniform market.

Irregularity of coal production is due to a seasonable demand, this coming in the fall and winter. Thus it is feast or famine with the coal producing company and, further, the burden of transportation is thrown on the railroads just at a time when it is most difficult for them to make prompt and assured deliveries.

This problem resolves itself into one which can be stabilized, but to do so action must first be taken by the ultimate purchaser or consumer. Both the carrier and the producer are powerless to act unless the consumer will place his orders so that the burden will be well distributed throughout the year rather than be crowded not only into a few months of intense activity, but into just about the worst months of the year. In the last analysis it will be the consumer who will profit most by an improvement of the extravagant methods which have been and still are being practiced.

Within just the last few months the American Engineering Council has issued a report on the subject of industrial coal. In this report it is recommended that all coal consumers purchase their coal on an annual contract for yearly requirements with a provision that the coal be delivered monthly in equal allotments; also that consumers provide the necessary storage facilities to meet the terms of such a contract. Such a practice, it is felt, will result in a condition wherein:

(1) Coal mines may inaugurate and maintain a regular and uniform production schedule.

(2) Carriers may plan definitely as regards both schedules and equipment for a uniform movement of coal.

(3) Stocks of coal will automatically accumulate during the months from April to September inclusive in sufficient amount to meet the extra consumption during the winter months, and

(4) Reduction in the price of coal will be made possible by more regular schedules of production and transportation and by the elimination of peak demands during the winter months when the costs of production and transportation are at their highest.

Estimate of Storage Capacity

Factors involved in the study of the problem of coal storage are: amount of storage, system of storage, depth of the pile and provisions against heating, these being dependent in a great measure upon the kind of coal which is most economical to use at the location under consideration. It is common practice to carry in stock from seven to eight per cent of the annual consumption. On this basis, it is evident that about 10 per cent of the annual consumption should be stored during the spring and summer months in addition to the minimum requirements stated above. The sum of these figures would indicate the average storage capacity, that is, 8 plus 10, or about 18 per cent of the annual requirements.

Selection of the type of equipment to be used in storing and reclaiming coal is largely dependent upon the quantity of coal to be stored. It would be unwise obviously either to install an elaborate system for a small plant or one which was inadequate for a large plant. The factors which must be considered are: size and shape of the storage plot, method by which the coal is received, amount of coal to be handled, cost to install and operate, character of the coal and, in some cases, climatic conditions, for it is obvious that under-water storage cannot be used successfully in a cold climate during the winter months.

Hand operated methods of storage can be used only for the smaller plants. This method usually involves shoveling or dumping from a car and then conveying the coal to the furnace either by hand or an inexpensive arrangement of conveyors, such as portable belt conveyors. It would appear as though this method could best be adapted to plants storing about 1000 T. and consuming not over say 5000 T. per year.

For plants which store from 5000 to 7500 T. per year a simple arrangement consists of a locomotive type of crane operating either on a ground level track or on a trestle and storing coal on both sides of this track. A crawler type of crane is economical of first cost and is often an advantage where the shape of the storage space is irregular or practically square. It is free to move regardless of track facilities, however, it is not as handy as the track crane because the latter can be used to switch cars about the yard without providing any other roadway than the track. Cranes can be had which have combination wheels to run either on a track or on a roadway. Where the load is carried on four wheels a good firm roadway must be provided. This is often taken care of by storing the coal on a concrete floor.

This system may be extended by placing two tracks or two trestles parallel to each other. Trestles from 10 to 15 ft. high are usually located about 30 ft. apart. A pile of anthracite 25 ft. high, the angle of repose of which is about 27 deg., contains about 67 T. per running foot. Bituminous coal, which has an angle of repose of about 40 deg., would average 63 T. per running foot for a pile 25 ft. high.

Loading Capacities of Cranes

Locomotive cranes can load faster than they can unload cars. A crane with a 2-yd. bucket can be expected to unload from 10 to 15 cars in an 8-hr. day, whereas it can load from 20 to 25 cars in a 10-hr. day. The crane requires two operators and in addition two men are required to shovel out the cars and clean the track. Cold weather and handling large coal are two factors which cut down on the capacity of a locomotive crane.

It is often expedient to unload a car from the end, that is, with the crane and coal car on the same track.

Thus in selecting a crane, the boom must be chosen long enough so that when standing at an angle so that it will clear the end of the car, the bucket can be dropped to reclaim the coal from the far end of the car.

Self-propelled cranes usually travel at the rate of 4 to 8 mi. per hr. and can be had so that with a 35-ft. boom and a 2-yd. bucket they will handle from 1¼ to 1½ T. per min. at an average operating rate of 60 to 90 bucket trips per hour. A crane with a 40-ft. boom and a 40-cu. ft. bucket should make about the same number of trips per hour and handle from ¾ to 1 T. per min.

To increase further the storage capacity of the locomotive crane it is made to operate on a circular track. The storage capacity by this method may range up to 40,000 T. or above. The disadvantage of this system lies in the fact that the coal is usually laid over the track, thus making difficult, accessibility to that portion of the pile which may have become overheated.

Unloading from vessels or coal barges can readily be accomplished by a steeple tower from which a boom projects. The bucket load of coal is first hoisted, then drawn back and dumped into a pocket from which the coal is conveyed to storage. The steeple tower may be made either stationary or movable. A tower equipped with a 1½-T. bucket will unload up to 150 T. per hr. The next step in large quantity coal handling is the bridge crane. This is essentially a movable crane of the gravity type, which serves as a support for a grab bucket, a belt or some other conveying device. The traveling bridge utilizes to the fullest extent the ground available and it usually provides maximum speed with minimum labor for unloading. One example of this type of crane has a span of over 375 ft. and a travel of 1600 ft. and the storage capacity is close to 600,000 T.

Underwater Coal Storage

Storage of coal under water has been practiced to some extent. It is used principally for slack or small sizes of coal which give trouble from spontaneous combustion. It is claimed that storage under water prevents loss of heat value and that it is not accompanied by a change in physical properties. It is further claimed that the water retained by the coal upon its removal from storage is only that held by adhesion or capillarity.

Drag scrapers are also used for storing coal. These consist essentially of a scraper dragged back and forth over the storage area by means of a winding drum. The scraper line must be attached either to fixed anchors or a movable anchor car located at the outer edge of the storage area. Scrapers can be obtained in capacities up to 4 T. which will handle from 60 to 500 T. per hr. based on an average haul of about 100 ft. Cable speeds vary from 300 to 475 ft. per min.

Spontaneous combustion of coal is a subject which has received a great deal of attention, and, as a result, a number of practical considerations have come to light which, if practiced, will greatly reduce this hazard of coal storage. In the first place, the kind of coal stored is extremely important. Anthracite is practically free from this phenomena, whereas the high volatile coals, such as bituminous, semi-bituminous and lignites, are liable to give trouble.

Opinion is generally expressed that the oxidation of the pyrites content tends to raise the temperature of the coal. This being the case, it is no doubt a contributing factor towards the combustion of coal in storage. It has also been observed that coal which is pure, that is, without a large per cent of extraneous matter, is liable to heat. This is explained in that pure coals are able to condense and absorb oxygen more rapidly than other coals and so cause an increase of temperature. Spontaneous combustion is often traced to the temperature of the coal. Sources of heat may be flues, steam pipes or even direct exposure to the sun. This heat raises the temperature of the coal with the result that the rate of oxygen absorption is accelerated and thereby the temperature is still further raised, resulting in ignition of the coal.

It is an established fact that inflammable gases are in coal. These gases are not in themselves a cause of combustion but as the coal becomes heated, the temperature of the gas may become high enough so that it will unite with the oxygen of the air and thus constitute a source of danger. The presence of moisture in the coal apparently assists the pyritic oxidation. Moisture also plays a part due to alternate freezing and thawing, whereby the coal is broken up, thus exposing more surface to the oxygen of the air. It is also thought that moisture acts as a catalytic agent between the carbon and the hydrogen or unsaturated bodies of the coal and the oxygen of the air.

It has been observed time and time again that fine coal is a much more active absorbent of oxygen than coal of larger size, thus making the former more liable to spontaneous combustion. Coal of mixed grades tends to settle when stored so that the fine coal is at the bottom, thus creating a condition at that point which is favorable to spontaneous combustion. It is, therefore, advisable not to store slack and in any event to handle and lay the coal so that it will not be broken up further and so that the large coal will not be separated from that of finer size.

One school of thought insists that pressure is a contributing cause of spontaneous combustion and, therefore, it is often recommended that coal be piled to no greater depth than 15 to 20 ft. The accessibility of oxygen is to be avoided wherever fine coal is stored. Screened lump affords a small total area exposed to the oxidizing processes and further affords an opportunity for the air to circulate, thus carrying away heat as fast as it is formed.

Grade of Coal Is Important

Loss of heating value in storage varies somewhat with the grade of coal stored. Illinois coal loses within a year from 1 to 5 per cent. Pocahontas coal loses about 0.4 per cent of its heat value the first year of storage and about the same per cent the second year. The general opinion is that the loss of heat value is small and should not deter anyone from storing coal. Burning qualities of coal do not seem to be materially influenced by storage except that some volatile may be lost and extraneous materials may be picked up with it when the coal is reclaimed.

Some of the more important considerations to be taken into account when preparing to store coal are as follows: the storage space should be dry and well drained, a hard clay surface being desirable. The ground should be cleared of refuse and vegetation and the coal should not be laid on ashes. Space should be provided so the coal can be moved or spread out if heating occurs. New coal should not be stored over old coal which may have already started to heat.

It is always an advantage to store coal so that any part of the pile can be removed promptly. The depth and area of the pile is determined largely by the space available and the mechanical appliances used. The deeper the pile the more difficult it is to inspect it and remove it in the event of trouble and a number of small piles is ordinarily better than one large pile. Water is an effective way of quenching a fire only if it can be applied in large enough quantities and at the right point to effectively cool the mass. When any spot in a coal pile reaches a temperature of about 140 deg. F., it should be carefully watched. When the temperature reaches 160 deg. F., the coal should be removed and should not be replaced in storage until it has cooled off. It is always best to move coal before it begins to smoke, which it does when at a temperature of about 180 deg. F.

Coal pile fires may be detected by watching for evidences of steaming or by noting the odor which is given off. Heated coal readily makes itself known in winter by melting of the snow at that point. An iron rod may be driven into the pile and its comparative temperature noted with the hand upon its removal. Thermometers or pyrometers may be used to read directly the temperature at various points within a coal pile.

Extraction Engines for Industrial Power Plants

How Considerable Economy May Be Effected by a Judicious Combination of Power and Heating Loads. By F. Johnstone-Taylor

FACTORY OWNERS and power plant engineers faced with the problem of economical power generation have the choice of purchased electric power on the one hand and a variety of prime movers on the other. In many industries, no doubt, where electric power can be purchased at a cheap rate, electricity is in every way desirable, while as an alternative the gas and oil engine both have strong claims. There are a great many industries, however, among which may be cited, practically all chemical industries, paper mills, breweries, sugar refining, woolcombing, bleaching, tanning, dyeing and finishing works, etc., where the demand for steam for other purposes than power practically dictates that the power plant shall be steam operated.

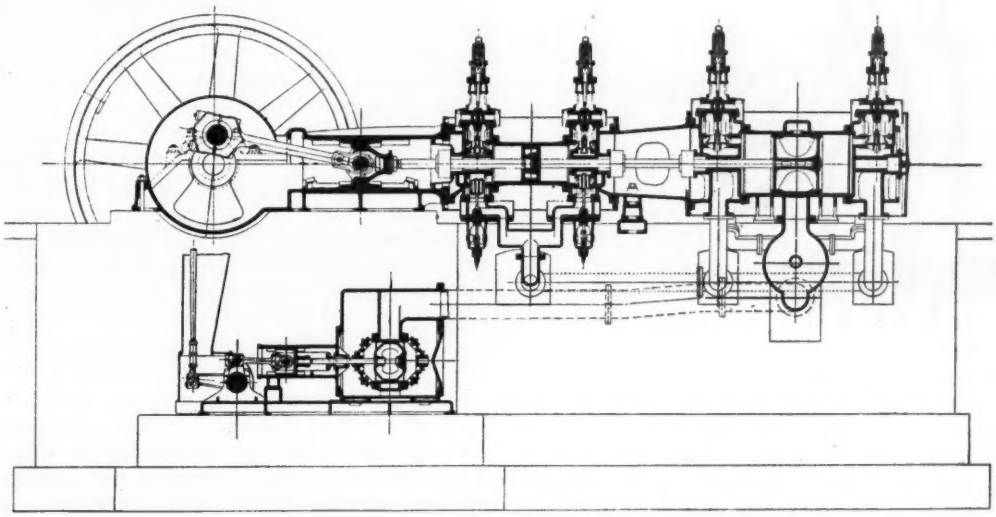


FIG. 1. LONGITUDINAL SECTION THROUGH THE GALLOWAY ENGINE

The Case for Engines of the Slow Speed Class

Of late years many claims have been put forward by builders of steam turbines in favor of that type of plant even to the extent of direct drive by geared turbines when electric transmission is undesirable. The steam turbine is in every way an excellent class of prime mover and its position in the electrical and marine fields is undisputed, but it has yet to be demonstrated that it has any marked superiority over the "high-class" steam engine for general industrial work. By the term high class is meant slow-speed uniflow and drop valve compound engines of the mill engine class. Although somewhat costly to install, this type of engine invariably proves a good investment. It is economical of steam. It does not demand on the score of economy steam at other than a moderate pressure and superheat, its steadiness of running complies with the most exacting requirements and its slow speed means that wear and tear are reduced to the minimum without comprehensive lubricating arrangements. Its efficiency may be maintained at a high level almost indefinitely while nothing particularly elaborate in the shape of condensing plant is called for. The slow-speed steam engine is, in fact, a sound engineering and commercial proposition which is enhanced by its marked immunity from breakdown.

The Use of Exhaust Steam

Process work demands steam at low pressure. To produce steam at low pressure, that is from 10 to 45 lb. per sq. in., is not an economical procedure and although reducing steam from, say, 200 lb. to the required pressure by means of reducing valves is both feasible and simple, that again is not economical. Nor is the mere drawing off of exhaust steam and passing it into the factory main indis-

criminately a very good solution of the problem. The case for the extraction engine lies in this, that by generating the steam at high pressure the cost of doing so is little more than that of generating it at low pressure and the power which it gives up to the engine during the period in which it is reduced in pressure entails but little diminution in its heating capacity. There is a tendency to use steam for process work at altogether too high a pressure. The all-important quantity is the heat quantity in the heating apparatus. The temperature of the steam is of but secondary consideration. In order to obtain the maximum economy in an exhaust steam utilization plant the pressure must be kept as low as possible. Of course when a certain

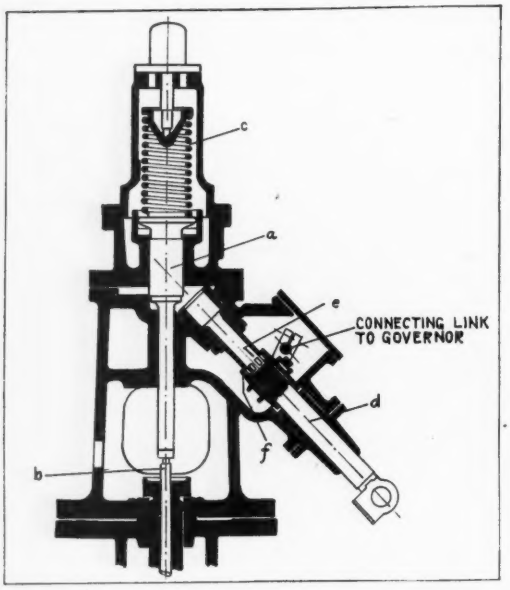


FIG. 2. VALVE GEAR OF THE GALLOWAY SYSTEM

temperature is essential the pressure of the heating steam at entry to the apparatus must be sufficiently high to ensure that this temperature is available not only as superheat temperature but also as the temperature of saturation. The actual process of heating is the release of heat contained in the steam and this takes place at saturation temperature and not at the superheat temperature pertaining at the inlet, the major portion being liberated as soon as condensation takes place.

Some General Considerations

If heating steam is generated in a low pressure boiler it would be generated at a pressure no higher than that required by temperature conditions. On the other hand if it were required first to drive an engine, then the pressure and temperature must suit the conditions of that engine. This immediately suggests a greater fuel consumption. It must be borne in mind, however, that the physical properties of steam are such that to increase the pressure and temperature to such an amount as would be required by the average high-class engine requires but a small fraction of extra heat accounting for not more than about 10 per cent increase in the fuel consumption. In addition the operating and other charges of a low pressure boiler will not necessarily be less than that of a modern one working at say 200 lb. and if the latter is fitted with mechanical stokers the reverse may well be the case. As a general rule, an extraction or back pressure engine suitably installed under conditions favorable to its use could, for this extra 10 per cent of fuel, provide considerable power dependent of course upon the amount of low pressure steam used. In other words, the manufacturer has all the advantages of producing his steam at high pressure and obtains his power, or a large proportion of it, in what is virtually the pressure reducing process.

The Theoretical Aspect

In the condenser of a modern engine, about 75 per cent of the heat supplied to it must of necessity be absorbed in the condensing water. Under certain conditions—that is when the whole of the exhaust steam can at all times and at all loads be utilized in the factory—a back pressure engine may be used. This is simply a matter of properly arranging a non-condensing engine to exhaust into the heating system. Superheated steam is essential because the economical working of this system lies in providing for the largest available heat drop in the engine, which is governed, not so much by the initial pressure as by the amount of initial superheat.

Of course with a non-condensing engine the steam consumption will be in the neighborhood of 16 lb. per i.hp.-hr. as against say 11½ in the case of a condensing engine. Assuming, however, that the engine hp. is 400 and it utilizes steam at 170 lb. pressure and 575 deg. superheat, then if working as a back pressure engine consuming 400 × 16 = 6400 lb. of steam per hour, this is exhausted with a heat value of say 1150 B.t.u. per lb. = a total of 7,360,000 B.t.u.

The condensing engine, while consuming only 4600 lb. per i.hp.-hr., still leaves 7,360,000 B.t.u. to be provided for and as this would account for something like 5620 lb. of steam per hr. there would be a total of 4600 plus 5620 = 10,220 lb. of steam to be found as against 6400 lb. in the first instance. The saving is therefore obvious.

Conditions suitable to this simple arrangement, however, are not often met with in practice; that is to say, the heating system cannot run in synchronism with the power load. This, with a non-condensing engine, means drawing off live steam reduced in pressure at one time and exhausting into the atmosphere at another. These conditions are provided for by compound engines of a special type which will be described presently.

As an example of the working conditions a tandem drop valve engine is taken developing at normal rating 275 b.hp. with a maximum power of 350 b.hp. Steam is supplied at 150 lb. superheated 150 deg., the extraction pressure being 28 lb. and the vacuum 26½ in. The average demand for heating steam is 3000 lb. per hr. Under these conditions about 4750 lb. of steam would pass through the hp. cylinder and allowing for losses in the receiver, some 1750 lb. would pass through the low pressure cylinder to the condenser. For the power developed, therefore, of 275 hp. the net water rate would be 6.3 lb. per i.hp.-hr. In the case of separate supplies for heating and power the water rate of the engine could hardly be expected to be much under 11 lb. per i.hp.-hr. or, say, 3025 lb., which together with the 3000 lb. of steam cited before as the heating demand would give a total of 6025 as against 4750. This shows a net saving of 21 per cent and as the average water rate for an ordinary factory steam engine would be more in the neighborhood of 25 lb. per i.hp.-hr. than 11 lb. as

quoted for the high-class engine the actual saving effected by the installation of an extraction engine would be sufficient to pay for its cost in a short time.

British Extraction Engines

Most British builders of high-class steam engines have taken up the extraction engine while the development of the system in Europe by Sulzers is worthy of mention. Generally speaking the engines take the form of horizontal tandem compound engines. Some designs provide for both cylinders being of the drop valve type; others make the low-pressure cylinder a uniflow cylinder. The working conditions call for a somewhat small low-pressure cylinder and a rather large high pressure one; they may, in fact, under some circumstances be of equal size.

Figure 1 shows a design by Galloway which it will be seen has a uniflow low-pressure cylinder. In passing, mention may be made of an interesting system of valve operation used by this firm. Referring to Fig. 2, the valve is lifted by oil pressure admitted under plunger a, which is connected to valve spindle b, the spring c serving to reseat the valve. An eccentric on the lay shaft in place of operating the valve through the usual medium of a trip gear operates the ram d. This creates the oil pressure.

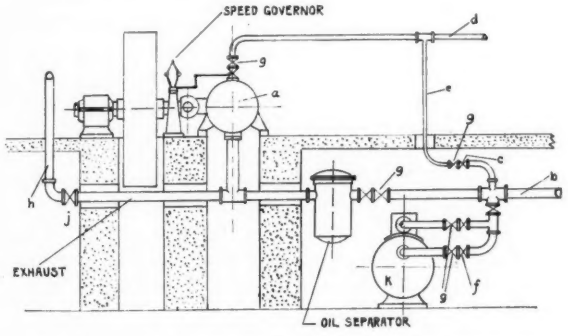


FIG. 3. BACK PRESSURE ENGINE CONTROL SYSTEM

The top portion of the ram is hollow and has ports e. The sleeve f is under the control of the governor and at a predetermined point uncovers ports e and so releases the oil pressure, constituting, in effect, a trip gear.

Regulating Gears

The essential feature of the steam extraction engine lies of course in the arrangement for balancing the power and heating loads by means of which all steam rejected by the heating system is caused to do work in the low-pressure cylinder. Its duty is automatically to maintain a steady pressure in the receiver pipe. When the requirements of steam extraction are at a maximum, little steam is permitted to pass into the low-pressure cylinder so that practically the whole of the steam in the high-pressure cylinder is taken away as extraction steam. The engine, therefore, virtually works as a single-cylinder engine, the regulator having brought the low-pressure valve gear to its point of earliest cutoff. As the demand for extraction steam decreases the cutoff in the low-pressure cylinder becomes later. More steam is taken and the engine tends to speed up. This, however, is immediately checked by the sensitive governor altering the cutoff in the high-pressure cylinder, an arrangement which limits the change of speed, limits the change of pressure in the receiver pipe and transfers part of the mechanical load to the low-pressure cylinder.

When there is no demand at all for extraction steam the engine works as a normal tandem condensing engine. The amount of steam condensed will be comparatively small because normally the low-pressure cylinder deals only with the difference between the total steam supply and the extraction steam so that a simple jet condenser usually suffices for this purpose.

Sulzers System

Figure 3 illustrates an arrangement applied to a simple engine as built by this firm. Presuming the engine to be delivering an insufficient amount of steam for the heating system, the pressure in heating main b tends to fall and

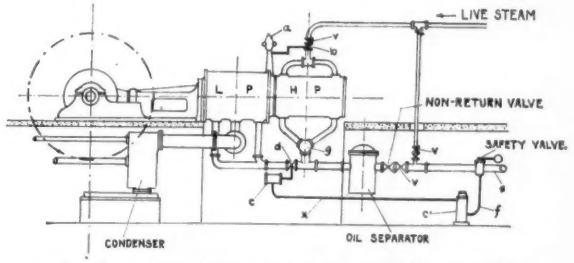


FIG. 4. EXTRACTION ENGINE CONTROL SYSTEM

automatic steam-reducing valve c admits live steam from main d via pipe e. As soon as the pressure in b is restored to normal, the reducing valve will close automatically. Check valve f prevents steam flowing back from main b into the engine while valves g—g serve to isolate the various sections of piping when necessary. If the engine is exhausting more steam than can be used in the heating system, then it has to be released through pipe h and safety valve j, a condition of affairs which must of necessity be uneconomical unless a heat accumulator is provided as shown at k. In this connection it might be mentioned that a heat accumulator is a valuable piece of apparatus in industrial systems for maintaining a constant steam supply with the smallest possible boiler plant.

Compound Engines

Figure 4 shows the arrangement as applied to a compound engine, the working of which has already been touched upon. It is adaptable to a wide variety of conditions. At times of maximum heating demand, for instance, the low-pressure cylinder is merely fed with drifting steam, the high-pressure cylinder taking practically the whole load and the engine working as a back-pressure engine. The valve gear of each cylinder has its own independent governor, one a controlling valve b of the high-pressure cylinder and the other c which is a pressure regulator controlling valve d of the low-pressure cylinder.

Presuming the load as constant for the time and an increase occurs in the demand for heating steam, the pressure in main e will fall. Pressure regulator c, which is connected with e by small pipe f, curtails the steam admission to the low-pressure cylinder, thus providing for the bulk of the increased heating steam demanded. In the meantime the reduced steam passing to the low-pressure cylinder tends to slow up the engine, which is counteracted by the governor a, altering the cutoff of the high-pressure cylinder, so bringing the speed and power of the engine back to normal.

The regulator c′ is seen to be in two parts c and c′; these, the regulator proper and the servo motor, are shown

in Fig. 5 A and B. The pressure transmitter A consists of a vessel which is connected by means of pipe a to the heating main in which a constant pressure is required. The connecting pipe is so arranged that water can accumulate in it and water only and not steam has access to chamber b. Above the water this chamber is filled with oil, the quantity of which can be adjusted at c, the dividing level of the two liquids being visible in a gage glass (not shown). In this manner piston d, by being prevented from coming in contact with any moisture, is immune from corrosion. The piston rests through rod e against piston valve f loaded by spring h.

Any pressure increase in chamber b causes the piston and valve to rise until overcome by the spring. Each position of d and f therefore corresponds to a definite oil pressure in b and a certain pressure in the heating pipe. Each position of valve f also results in a definite throttle effect establishing a definite pressure of oil coming from the servo motor through pipe x (see also Fig. 4), pipe g being the oil drain. This pressure transmitter therefore serves the purpose of transforming each steam pressure in the heating pipe into a definite pressure of the regulating oil in the connecting pipe x (see Fig. 5 B also). The servo motor (Fig. 5 B) consists of a cylinder fitted with a differential piston a. Pressure oil—supplied usually from the engine lubricating system—is fed through pipe b into annular chamber c. Some of the oil leaks via groove e into chamber e to which pipe x is connected. Should the pressure fall in x and in consequence in e, piston a will move downwards because the oil in chamber c is unaffected. The piston rod f then operating upon the cutoff gear of the cylinder alters it. Should the back pressure of the engine tend to fall owing to increased extraction, piston d (Fig. 5 A) with its valve f will move downwards. Oil escaping from j will be subject to a greater throttling effect, causing an increase of pressure in pipe x and chamber e. Piston a (Fig. 5 B) is then forced upwards and the cutoff altered in the other direction. Provided the components of the regulator and servo motor are constructed with precision, this method of control can be made extremely sensitive so that with the greatest variations in steam extraction the pressure fluctuation is hardly noticeable, while the economy of the system has been proved beyond doubt.

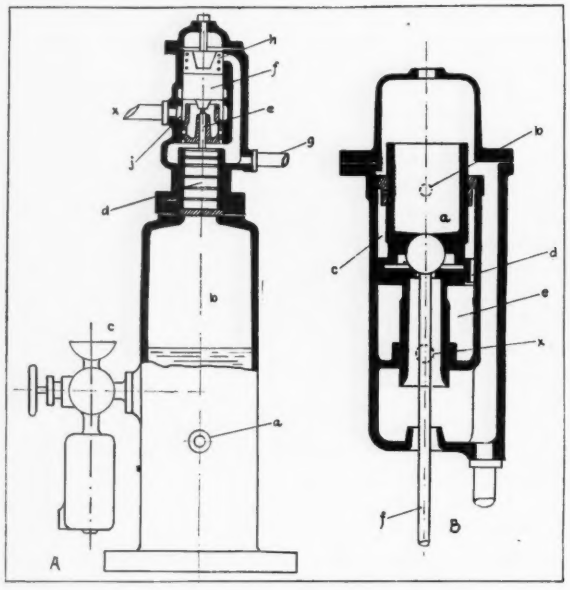


FIG. 5. DETAILS OF REGULATOR USED IN CONNECTION WITH COMPOUND ENGINES. (A) REGULATOR PROPER. (B) SERVO MOTOR

Saving in Fuel

Seeing that the installation of an extraction engine involves a somewhat heavy capital cost, the prospective user naturally looks to a considerable saving in fuel cost to compensate for it.

Assuming, writes Dr. Morley, a well-known exponent of the system, that a factory requires a load of 500 i.hp. and process steam at 25 lb. per sq. in. to the extent of 5000 lb. per hr., then with steam generated at 160 lb. per sq. in. and superheated, an extraction engine would require about 8350 lb. of steam per hour. If power, however, were produced by a condensing engine of good type without extraction, even at the low steam rate of 11.3 lb. per i.hp.-hr. the engine alone would require 5650 lb. per hr. Adding the steam required for heating, a total of 10,650 lb. per hr. would have to be generated. The coal consumption is practically proportional to the steam generated, as even if the heating steam were generated at 25 lb. per sq. in. the difference in coal consumption as compared with generation at 160 lb. per sq. in. is small. Thus in comparison with the separate system the saving in fuel due to the extraction engine is $(10{,}650 - 8350)/10{,}650 \times 100$ equals 21.6 per cent. The saving in a 70-hr. week in the case given would be about 10 T. of coal. In addition there is a saving in condensing water handled; the boiler plant would be rather smaller and less costly; the cost of coal and ash handling would be reduced, while the engine attendance charges would be no more than with any other type of engine.

"Our small towns are being reborn. Electrical power is starting long-idle factory wheels, building new plants, bringing better roads, higher wages and a better way of life. High-tension wires are putting the pleasant, happy small town of American tradition on its feet—to stay." Commenting on that editorial, the Dixon Tribune says: "The small town is as well lighted as the city. It has the same advantageous power connection for manufacturing as the city. Given advantageous shipping facilities, small towns are now attractive to manufacturers because of less valuable sites, cheaper rents and less temptations for employes."

One more thought should be added to the foregoing comment, says the Fairport, N. Y., Herald. Advocates of public ownership have been attempting to show that state or government development of electric utilities is necessary to give the people service. No more misleading or erroneous statement could be made. So-called super-power projects, which are glibly talked about by politicians, are mere phrases to catch the public fancy. Long transmission lines stretching for hundreds of miles to small towns and farms far distant from the source of power would not be a fact today and in common use if private utilities had not perfected so-called "super-power systems" through interconnection of transmission-line resources and development of great hydroelectric and steam plants, long before the politicians ever invented the words "super-power."

Stoker Operation Improved by Simple Changes

CHAIN GRATE STOKERS PRESENT PROBLEMS IN AIR AND FUEL DISTRIBUTION, ARCH AND WATERBACK ARRANGEMENT

EARLY installations of the forced blast traveling grate or chain grate stoker usually provided for the introduction of air only along one side of the stoker. In many cases, where the stoker was only 8 ft. wide or less, this arrangement was entirely satisfactory. But with wider stokers a difficulty arose which often seriously affected the uniform burning of coal on the grate.

Ordinarily, air is supplied to the stoker with a static head varying between 2 and 5 in. of water, giving a velocity, in the case of air supplied from one side, sufficient to create a partial vacuum or down-draft through the fuel bed on the side of the stoker nearest the point of air introduction, while undue pressure was built up on the farther side. This resulted in complete combustion of the fuel at the point of highest pressure, while a strip of fuel 2 or 3 ft. wide, along the side where the air was introduced, was only partially burned. This is shown in Fig. 1.

AIR BAFFLING

Various schemes of air baffling were tried but without success until somebody hit upon the idea of interposing a

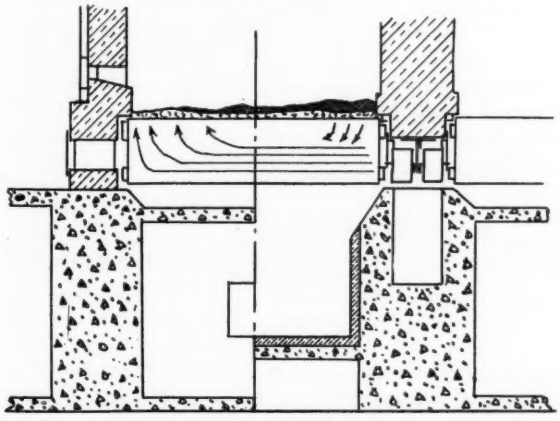


FIG. 1. AIR DISTRIBUTION UNDER CHAIN GRATES FROM ONE SIDE ONLY, CAUSES UNEVEN BURNING ACROSS THE WIDTH OF THE GRATES

portable baffle, set vertically and directly in the path of the incoming air. It consisted of nothing more than a perforated piece of sheet metal welded to a strip of angle iron, which, in turn, was welded to two other short strips of angle iron, serving as legs. See Fig. 2.

By removing the clean-out doors, one of these baffles was placed in each air compartment; then, by means of a jointed rod, which could be attached after the baffle was placed inside, each baffle was pushed along the floor of the compartment until a point was reached where it was thought the air would be retarded sufficiently to give an even distribution to all points through the fuel bed.

After the clean-out doors were replaced, air was admitted and the effect of the baffles observed. There was no definite method of deciding just where the baffles should be placed, but at first it was believed that a distance of 3 or 4 ft. from the air inlet would be about right. By closely watching the fuel bed, it was subsequently found that best results were obtained when the baffles were placed from 12 to 18 in. from the dampers. The average cross sectional area of the air compartments was about 12 in. high by 24 in. wide so that the extent of the restriction offered by the baffles may be judged by comparing these figures with the dimensions of the baffles shown in Fig. 2.

In most cases, in order to push the baffles back into the compartments, it was necessary to use jointed rods made in sections of 3 to 5 ft. since adjoining furnaces were so close that a single length of rod could not be used.

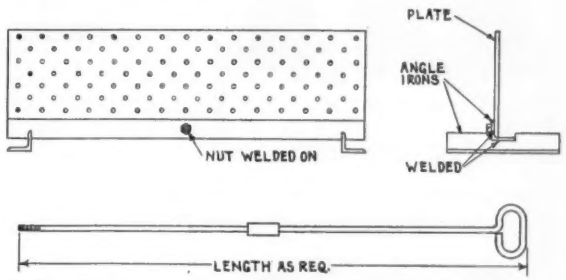


FIG. 2. BAFFLE AS USED IN COMPARTMENT FOR CONTROLLING AIR DISTRIBUTION

Due to the fact that a certain amount of fuel and ash siftings accumulate in the compartments and must be raked out through the clean-out doors, the portable baffle was necessary so that it could be removed while cleaning.

In most power plants, a search of the scrap iron pile will generally reveal sufficient material to make baffles as described above. It requires little skill to assemble the parts and, if a welding outfit is not handy, the pieces may be bolted together.

FUEL SEGREGATION

In addition to faulty air distribution, power plants having chain grate stokers are often troubled with poor coal sizing and subsequent segregation of coal particles due to this sizing. Most chain grate stokers, whether natural draft or forced draft, are designed to burn what is generally known as "1¼ in. screenings." This means that all of the fuel must pass through a round-mesh screen with openings 1¼ in. in diameter. The largest lumps will be of this size, while most of it is generally of particles no larger than ½ in. diameter.

Care must, therefore, be taken in the method in which the fuel is fed to the stoker hopper. If it is allowed to avalanche out of a round spout or spouts suspended above the hopper, there is great danger that, as the fuel slides through the spouts, it will separate, the larger lumps being thrown to the outside, so that distinct segregation of fuel particles will be noticeable in the fuel bed. A number of plants have experienced this difficulty, which not only affected combustion conditions but gave rise to other troubles. In one of the plants which we have in mind, the fuel was fed to the hopper through three round spouts with the ends flared in bell-shape as shown in Fig. 3.

This segregation of fuel particles caused two distinct streaks or grooves down the center of the fuel bed and also a streak along each side. The streaks or strips along the side in which the fuel was burned down nearer to the grate

were not so noticeable as those in the center, since combustion in the fuel bed is usually more complete along the sides than in the center. This is due to greater air leakage and more rapid burning. The grooves in the fuel bed on either side of the center spout were distinctly noticeable but operators did not realize what was causing them nor did they connect the cause of these grooves with another and even more serious difficulty—that of arch erosion.

Air naturally follows the lines of least resistance and will accordingly pass through the fuel bed along points

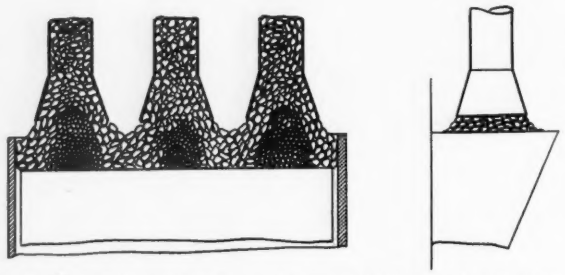


FIG. 3. FUEL DISTRIBUTION WITH ROUND SPOUTS DISCHARGING ABOVE LEVEL OF FUEL HOPPER

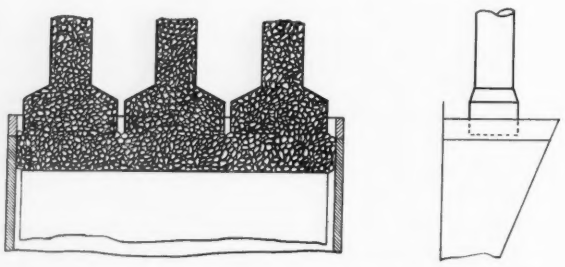


FIG. 4. FUEL DISTRIBUTION WITH FLATTENED SPOUTS DISCHARGING BELOW LEVEL OF FUEL HOPPER

where the fuel particles are coarsest. This obviously causes a greater evolution of gas along the strips of coarse fuel. So much gas is generated above these narrow strips that complete combustion of much of this gas is not effected until it strikes the arch. This causes higher temperatures just above the strips of coarse fuel than at other points, with a resulting softening of the arch. With these longitudinal strips of the arch softened by the high temperature and a greater density of gas along these lines it is quite easy to see what would cause distinct grooving or erosion of the arch as the gases sweep around the end.

Remedy for this trouble was quite simple and it was only necessary to alter the method of supplying fuel to the hopper. This was done by removing the round, bell-shaped flares on the ends of the spouts and substituting sections which were flattened out as shown in Fig. 4, allowing more fine particles to be dropped across the width of the stoker. In addition, the sides of the fuel hopper were extended above the old level, so that the ends of the spouts would be covered at all times, if the hopper and the spouts were kept filled all the way up to the bunker above. In this way the larger lumps did not roll to the outside and there was no distinct segregation.

After the fuel spouts were changed a marked improvement was noted all around. There was less carbon in the ash, a better quality of furnace gas, and no appreciable erosion of the arch.

Visits to a number of the older installations of chain grate stokers will reveal troubles which the modern furnace design has overcome. In a certain plant it was found that the ends of the links or clips, were being badly burned and, at first, operators were at a loss to know what caused it. It was finally agreed that the radiant heat from the bridge wall was reflected onto these links, just at the point where the flat grate surface was broken when it passed around the rear end of the stoker. In so doing, the rear end of each link is exposed and it is only a short time until corners are burned off. Waterbacks, as formerly installed, didn't help much for they didn't extend forward far enough to afford protection. Waterbacks weren't originally installed for this purpose anyway. The old purpose of a waterback was to scrape off and hold back any unburned carbon which might be going over the rear or top of the ash. Figure 5 shows such an installation.

In addition to allowing the clips to burn, the old-style waterbacks were inadequate in preventing stratification of furnace gases. Some idea of the way these gases and air were evolved is also given in Fig. 5. The waterback did

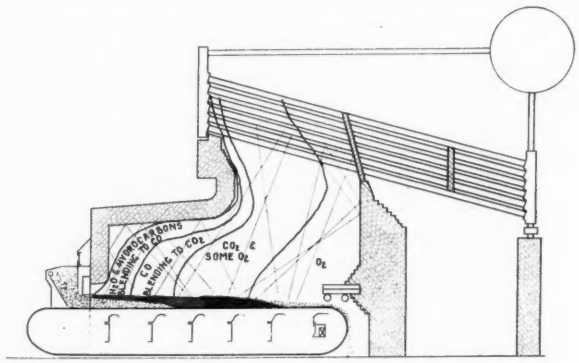


FIG. 5. SIDE ELEVATION OF CHAIN GRATE STOKER WITH WATERBACK

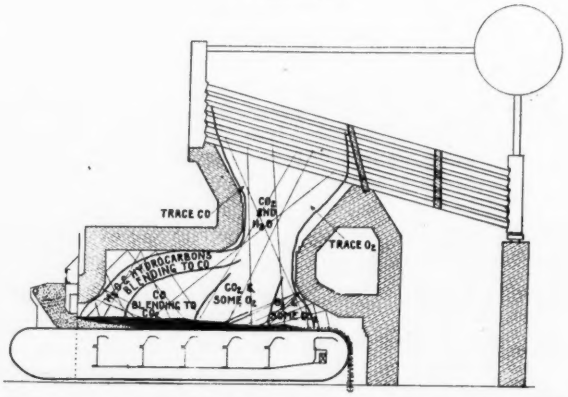


FIG. 6. SIDE ELEVATION OF CHAIN GRATE STOKER WITH SUSPENDED REAR ARCH

not extend forward far enough to cause the excess air, coming through the fuel bed and around the rear of the stoker, to mix with the unburned gases evolved in front. Water was usually circulated by means of a low-pressure pump, and, if anything happened to the pump for any length of time, a burnt-out waterback was inevitable. One day the expected happened—the pump stalled and couldn't be started for some time. When it was finally repaired the damage was done for the waterback had sagged, burnt in two and, as the tile slid off, part of the bridge-wall was loosened

and fell down. In view of the fact that a waterback wasn't of much use anyway, it was decided not to repair it but to remove it entirely and install a rear arch. As most of the material for this arch happened to be on hand it took but a short time to install it and the resulting improvements more than paid for the cost. The worry of a broken waterback was past, while the clips passing around the rear of the stoker were entirely shielded from radiant heat. An improved quality of the ash was noted, since the heat reflected from the arch effectively burned out the carbon. Excess air, at the rear of the stoker, was deflected forward into the path of the combustible gases and a complete mixing effected. This raised the average CO_2 content of the flue gas from about 10 per cent to 13 per cent and at the same time eliminated most of the smoke nuisance of which there had been much complaint.

It would be advisable for operators of chain grate stokers equipped with waterbacks to check up on all the losses this sort of equipment is giving them and to consider seriously the installation of some good type of suspended arch. If the setting is too low to permit this, a "sprung" arch, such as is often installed instead of a waterback in furnaces having low-set, horizontally baffled boilers, will serve the purpose.

Distilled Feed Water Helps Boiler Equipment

SCALED AND BURNED TUBES, FOAMING AND PRIMING, ARE REDUCED AND HEAT BALANCE HELPED

IN A RECENT discussion on this subject, Geo. H. Gibson tells how distilled water helps in reducing boiler troubles and how to use evaporators to give heat balance without decreasing "heat availability" in the plant. He also shows several methods of connecting evaporators into the feed water system as used in recent plants. The following article has been abstracted from that discussion.

In modern boilers, working at three or four times their nominal rating, much of the work must be performed in the last pass so that the surface in that part of the boiler can no longer be considered as reserve. If scale is permitted to form, it cuts down the average rate of heat transmission and the flue gases will be much hotter when discharged to the stack. Also the tubes will be likely to become overheated and burned, possibly to the danger point for, with steam temperatures approaching that at which the strength of steel begins to fall off rapidly, it is essential that the tubes be heated as little above steam temperature as possible. All this means that boiler tubes must be kept clean when boilers are run at high loads and this, in turn, means that the water must be pure when it enters the boiler.

Foaming and priming are caused by suspended matter and dissolved salts respectively. The foaming is increased by an excess of alkalis and behaves much like a light liquid so that often all the foam is not removed by separators. In the case of soluble salts, violent boiling is produced which causes water spray to be thrown into the steam space and in either case, entrained moisture may be carried into the superheater to form scale, or even beyond, where the dried salts and sludge will act like a sand blast on turbine blades and valve seats.

If evaporated water be used for boiler feed, it has the added advantage that it contains little air, hence will have little corrosive effect from nascent oxygen.

EVAPORATOR OPERATION

In the balance of the article, Mr. Gibson takes up the use of evaporators, their operation and their place in attaining heat balance without loss of potential heat energy. Conditions in evaporators are similar to those in condensers and boilers. On the steam side, air, if not removed, will blanket the tubes and lower the heat transfer. Also an oil film on the tubes will interfere with efficient action, hence, oil, if present, should be removed from the steam by an oil separator. On the water side, the chief troubles are from corrosion, scaling, foaming and priming so that the same precautions should be taken as in boilers. Water must be blown down occasionally; scale must be cracked off the tubes and removed, which can generally be done by turning high temperature steam into the evaporator. Priming and foaming can best be overcome by use of a film type evaporator, if the trouble is so serious that it is not obviated by reasonable blowing down.

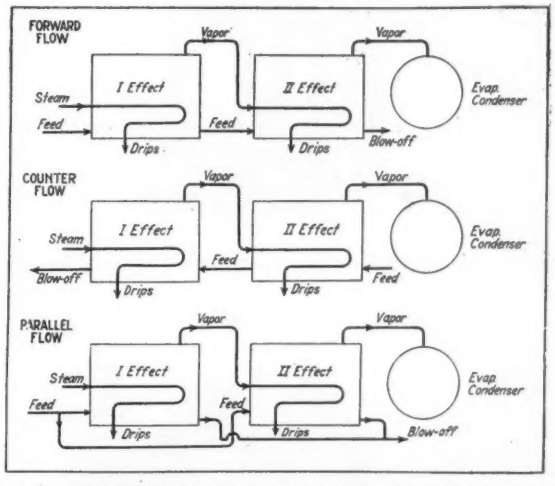


FIG. 1. EVAPORATORS MAY BE CONNECTED FOR FORWARD, COUNTER-CURRENT OR PARALLEL FLOW OF THE WATER

Two, three or four evaporators are usually arranged in series, the vapor from one being used as the steam supply for the next in the series, which operates at a lower pressure. These are known as double, triple and quadruple effect systems. Each additional effect will produce additional distillate per pound of steam, the amount varying from 0.7 lb. to 0.9 lb. on account of the variation in latent heat of steam with pressure, so that the quadruple effect will give about three times as much distillate as the single effect.

In a film evaporator, the capacity is proportional to the tube area and the temperature drop, hence two evaporators connected in multiple effect, with the steam flowing through them in series and the water in parallel, will give no more distillate than one of the effects alone but will save half the steam. This arrangement has the advantage, however, that, in case of emergency or for cleaning or repairs, one of the units can be shut down and the other

used to produce the full amount of condensate but with loss in economy.

In multiple effect evaporation, three classes of flow may be used, forward, counter-current and parallel. In the first, water enters the hottest effect and flows successively to the other effects, blowoff being taken from the coolest effect. In the second, water enters the coolest effect and is blown

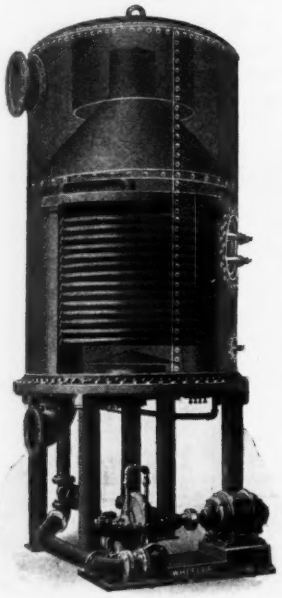


FIG. 2. IN THE FILM TYPE EVAPORATOR, WATER IS RECIRCULATED AND DESCENDS OVER THE COILS, VAPOR ESCAPING FREELY

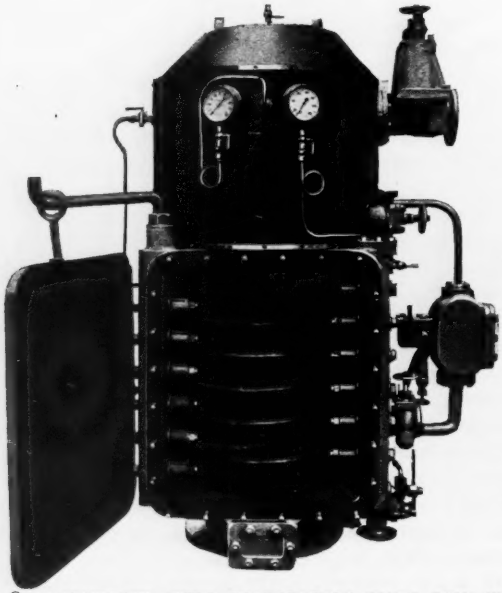


FIG. 3. SUBMERGED TYPE EVAPORATORS HAVE THE COILS COVERED AT ALL TIMES

off from the hottest. In the third, raw water enters each effect and blowoff is taken from each independently. When using cold water, counter-current operation gives a large part of the heating of the water in the lowest stage so that the decrease of production in that stage does not affect the other stages. In forward flow, all heat to raise the water to the temperature of the highest effect is supplied by the hottest steam, which gives a lower efficiency than the forward flow method. Part of this heat is recovered in the lower effects by flash evaporation of water as the temperature drops. Parallel flow is intermediate in efficiency between forward and counter-current methods, the production for a condition of steam at 225 deg., feed at 75 deg., blow down 5 per cent to the sewer and drips going to the evaporator condenser being 3.18 lb. of condensate for the counter-current per 1 lb. of live steam; 2.83 lb. for the parallel flow; and 2.5 lb. for the forward flow. Warm water used for supply gives the counter-current less advantage, the products for feed at 150 deg. and other conditions the same being, for counter-current, 3.43 lb.; for parallel flow, 3.38

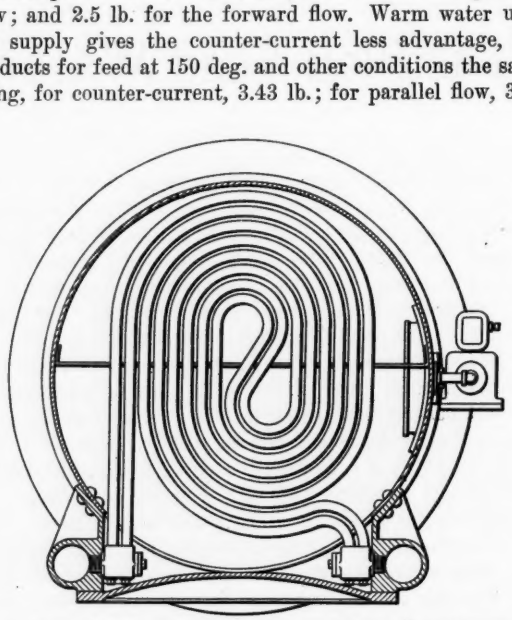


FIG. 4. DOUBLE CURVED COILS, "ELLIPTICOILS," ARE USED TO GIVE ADDED EXPANSION AND ASSIST IN CRACKING OFF SCALE

lb.; for forward flow, 3.32 lb. Spite of this disadvantage, the forward flow is generally used as it gives a natural flow of water due to difference in pressure without the use of pumps or possibility of the feed backing up. The mode of operation to be chosen depends on the relation between cost of steam and cost of apparatus needed to get the required amount of condensate and, where the same economy can be secured by means of heat exchangers, on whether additional pump capacity, heaters or evaporator surface is cheapest.

Types of Evaporators

For the submerged type, in which the steam coils are covered with water, medium pressure operation has the advantage that it reduces priming and loss from hydrostatic head and the evaporator may discharge its vapor to a deaerator or open heater, thus doing away with the evaporator condenser.

In the film type, shown in Fig. 2, water flows in a series of films from the distributing plate above the coils, such as is not evaporated being recirculated by the pump which takes its supply from the bottom, with a connection for taking in more raw water as needed. Vapor is discharged from the outlet near the top, after passing through the vapor dome and separator. Steam enters the nozzle shown at the left of the base and flows to a vertical header,

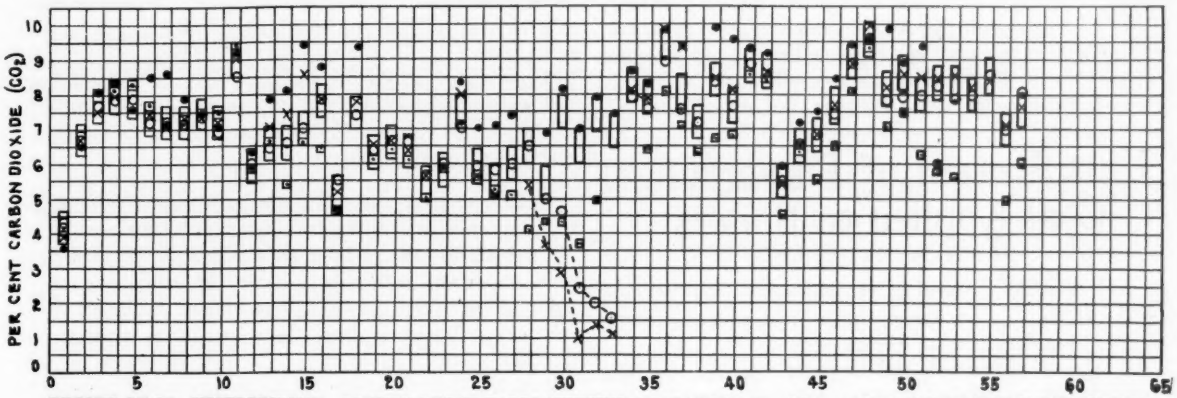
thence through ellipticoils, discharging as condensate into the vertical header at the right. The bolts for the drain outlet connection are shown between the two supporting columns at the right just below the bottom of the water chamber.

An example of the contraflo type of submerged evaporator is seen in Fig. 3. Steam flows into the coils, which are covered with water at all times so that no circulating pump is required, the vapor being taken from the upper nozzle. To give effective scale cracking, doubly recurved coils are used as shown in Fig. 4, the movement under the action of change in temperature being sufficient so that scale will crack off. It is stated that reversal of temperature every 4 hr. will maintain the tubes so clean that hand scaling is rarely needed.

Tests of CO_2 Recorders

By J. F. Barkley*

IN THE MATTER of boiler operation, a knowledge of the carbon dioxide content of the products of combustion from the furnace is valuable.



RECORD OF CO_2 INSTRUMENTS. WHERE POINT FALLS WITHIN RECTANGULAR AREA, ACCURACY OF THE INSTRUMENT IS WITHIN ½ PER CENT

An instantaneous indication of the CO_2 can be used as a useful guide to efficient burning. A permanent record over a period of time gives a story to the management which tends to keep the operators more alert. Many instruments that indicate and record CO_2 have appeared within the last 15 yr. More are about to appear. Although simple principles involving chemical, physical, or electrical qualities, are being used, there is at present a general feeling of uncertainty about such instruments in the boiler room. Many instruments are bought, run awhile, then lie idle indefinitely.

Inquiries as to CO_2 machines continually come to the Bureau of Mines from the general public, as well as from other branches of the Government. About 10 yr. ago a series of tests was made on certain instruments at that time on the market. The following test was made recently on four of the newer types, including one using an electrical principle. The four instruments were installed on one boiler each, according to the instructions of the makers, and the recommended routine attention was given them. The test was of a service nature duplicating the conditions under which the instruments ordinarily serve. The boiler that was available for this purpose was practically banked for some hours of the night. This caused the average CO_2 for the entire 24 hr. to be rather low, although it reached the higher ranges of the instruments during the day.

Each day the charts were averaged and the results plotted to form the accompanying curve. The record of each instrument is shown by its particular mark, the dot, circle, cross and square being used. In addition there is plotted for each day a rectangular area representing 1 per cent CO_2 in height. The proper position of this area was determined by means of the Orsat. Where the plotted point for an instrument falls within the rectangle its accuracy is within ½ per cent CO_2, which is considered satisfactory. Where it falls outside the rectangle, inaccuracy is indicated.

Study of the curve will show that for the first few days all the instruments were giving acceptable accuracy. Where a point does not appear for the day, the instrument did not give a record due to some of its own difficulties. At the place where certain points of the curve drop low and are connected with a dotted line, new chemical solutions were needed. This can not be charged against the instruments, as the change was delayed for the purpose of seeing the effect. One type gave continual trouble. The company's service man fixed it up on several occasions and certain changes were made according to his recommendations, but it would soon cease to function properly. No particular attentions were given the other three. At the end of the test two instruments were operating satisfactorily.

Determinations were also made as to the lag or length of time required for an instrument to indicate correctly major changes in the CO_2 content of the gas in the boiler. Factors affecting the lag are the length and size of pipe from the boiler to the instrument, the amount of gas being drawn through the pipe, and the action of the instrument itself. The instrument should be set as close to the boiler as possible. This is particularly true of the instruments that do not pull much gas through the line. Where there is much piping to reach the instrument, an auxiliary aspirator can be used to speed the gas through it. The lag in the instrument itself is affected by adjustments on the instrument. The following figures give an idea of lag values.

With 50 ft. of ½ in. gas pipe ahead of the instrument, the CO_2 content of the gas sampled was changed from 10 per cent CO_2 to 0 per cent. The length of time

* Fuel Engineer, Bureau of Mines, Dept. of Interior.

to show correctly this change varied with the different instruments from 4 to 20 min.

In general, the CO_2 instruments on the market give accurate results when all elements are favorable. There are many little things that might happen to disturb the accuracy. Most of these troubles are easily corrected. Some types are much more susceptible than others to these troubles. Some are equipped with trouble-saving devices that give more trouble than they save. Simplicity is highly desirable.

Unless full confidence in the accuracy of the instrument is maintained, it will soon be lying idle. In order to maintain this confidence, two things are necessary: A certain type of man and a good Orsat. The man must be one who enjoys working with an instrument and will learn every feature, so that there is nothing mysterious or uncertain about it. This is required of a man who cares for engines or stokers. The CO_2 instrument is a small machine of like nature. He should check it with an Orsat until he knows when it is accurate by its general working appearance so far as is practicable for the particular type. As with an engine or stoker, he must know what to do when any extraordinary event happens. Such a man using the better types of instruments can get results for long periods without much effort. If the record is not worth fulfilling the above conditions, it is hardly advisable to attempt the use of such instruments.—Reports of Investigations, Department of the Interior, Bureau of Mines.

Unit System of Pulverizing Coal Applied to Boilers

By Henry B. Jones*

AT A RECENT meeting of the New York Section, A. S. M. E. Mr. Jones discussed this subject along the following lines:

Storage of pulverized coal has now been in use long enough to be established as practical and economic for large sized plants but the cost of investment is often too great for plants using relatively small quantities of coal. For these, the unit system will solve the problem, but must be so installed that a spare mill is available for any boiler in case of breakdown.

No definite rule can determine which system will operate more economically, although it is generally agreed that the unit system has its greatest field in the case of plants burning less than 200 T. of coal a day.

Difficulties to be encountered are: First, maintenance of a uniform proportion of coal and air with fluctuating loads; second, uniform distribution of coal and air to all burners; third, distribution of the flame to utilize the entire furnace volume.

Changes in the moisture content of the coal will affect the coal output, but there will be no proportional change in the air supply.

Galvanized iron is usually used for piping from the machine to the furnace, with bends of large radius, preferably not less than five pipe diameters. Piping should run horizontally only for short distances as long, horizontal runs let coal drop out of the air stream so that drifts will form on the bottom of the pipe. Later on these will be carried to the burner in slugs, which will cause a smoky condition and sometimes extinguish the fire.

*Combustion Engineer, Fuller-Lehigh Co.

Piping should be divided into no more than two streams at any point, the angle of division being as small as possible; 90 deg. is a maximum and 60 deg. is to be preferred. Butterfly dampers in the piping should be avoided, if possible, as they are not satisfactory.

At the point where piping enters the furnace, air should be introduced around the pipe both for keeping the pipe cool and for assisting in combustion as the air introduced with the coal is not usually sufficient for complete combustion and if it is attempted to supply all the air through the pipes with the coal, too much power is used. Piping should be flattened where it enters the furnace because flat stream heats more readily than a round one and a better mixture with air is effected.

Ordinarily, a relatively large combustion space is required for powdered fuel but, since it is cheaper to build small furnaces, the problem for advocates of the unit system is to adapt it to existing conditions without radical changes in the furnace. With small furnaces, a short flame is necessary and there is need for efficient burners of the premixing type, which will give a short, hot flame and complete combustion close to the burner. Furnace volume may vary but in general need not exceed 1.2 cu. ft. per developed boiler horsepower, if properly designed. This corresponds to a combustion rate of about 27,900 B.t.u. per hour per cubic foot.

Any or all of the refinements, such as water-screened side walls and air-cooled walls, developed in the application of the storage system, may be used with the unit system, if cost and other circumstances justify.

Proper activities of trade associations were defined by a referendum of the Chamber of Commerce of the United States to be: That an association should exist for each important branch of industry or commerce, to consider all problems affecting the general advance of that industry. Statistics should be collected on capacity, production, stocks and sales and on actual prices in closed transactions, these statistics to be made available to the public and to government agencies. Trade associations should continue free from special forms of government control.

These points were brought out by E. W. McCullough, manager of the Department of Manufacture of the Chamber, in an address before the Glass Containers' Assn., when he also pointed out that record of government administration of the anti-trust laws did not show persecution of trade associations.

Suits have been brought only on premeditated or wilful violation of the laws and trouble may be avoided by remembering that the laws prohibit creation of monopolies, restraints in trade or interference with equality of opportunity.

Population of the United States was estimated, as of Jan. 1, 1925, at 114,311,000, a gain of 1,627,000 during 1924. This increase, according to figures compiled by the National Bureau of Economic Research, was made up of net immigration of 315,000 and excess of births over deaths, 1,312,000. The low death rate has been no small factor in this gain in population.

As to occupations, it is shown that somewhat over 38 per cent are working for remuneration, 10 per cent of these being in the management class. Two other groups, adults not working for gain and children under 15 yr. old, are each about the same size as the gainfully employed group.

Diesel Engine Overall Economy*

FIRST COST, OPERATING COST, UNIT COST, RELIABILITY AND COMPARATIVE COST FOR PUMPING. BY C. B. JAHNKE†

IT IS GENERALLY admitted that the Diesel engine is, thermodynamically, second to no other form of power generation. It remains to be shown that its overall economy, taking into account the investment and operating costs, merits the serious thought of power users when planning for additional power units.

Naturally, the question of present and future oil supply is pertinent and it is intended to throw some light on this subject.

OIL SITUATION IN THE UNITED STATES

Referring to Fig. 1, it will be seen that, since the beginning of the war, increase in the amount of petroleum produced and used has been rapid, also that the average price per barrel has fluctuated during this period. It

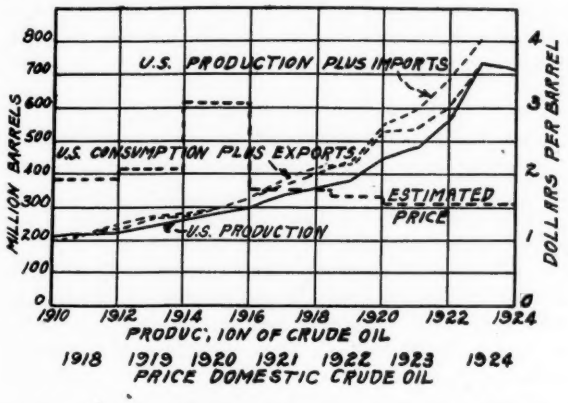


FIG. 1. ANNUAL PRODUCTION OF CRUDE OIL IN THE UNITED STATES AND PRICE FOR DOMESTIC CRUDE OIL

seems likely that the demand for oil will continue to increase, at least for a number of years, and that this demand will be met by stabilizing the present industry, by conserving its products and by the development of other sources of supply.

As to the remaining petroleum reserves, estimates that have been made disagree as shown in Fig. 2. The 1922 survey, made by the U. S. Geological Survey and the American Association of Petroleum Technologists, gave the reserve supply, recoverable by existing methods, as about 9,000,000 bbl. A joint governmental committee gave the following explanation of the oil situation: "The committee expressly decries the too frequent assumption that, inasmuch as the estimated reserves appear to be sufficient to meet the needs of the country, at the present rate of consumption, for 20 yr., therefore the reserves will be exhausted at that time or, at most, a few years later. This is absolutely misleading for the oil pools will not all be found within that length of time, drilling will be spread over many years as the wells are found and the wells cannot be pumped dry so quickly. Individual wells will yield oil for more than a quarter of a century and some wells will not have been drilled in 1950. In short, all the oil cannot be discovered, much less taken from the earth in 20 yr."

Since the last survey was made, developments have appeared that would likely bring about another upward revision of the estimate. Figure 3 indicates the large quantities of oil that have been obtained from only a few

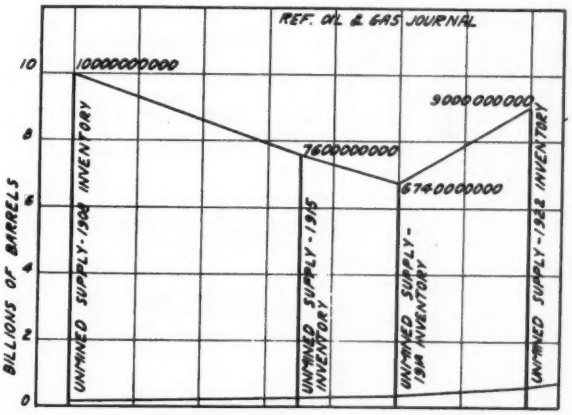


FIG. 2. ESTIMATES OF RESERVES OF CRUDE PETROLEUM IN THE UNITED STATES

of these fields which were then new or unknown. The whole record of production since the last survey has been such as to show that the estimate then made was too low.

Present methods of production secure but a comparatively small per cent of the total oil underground. It is

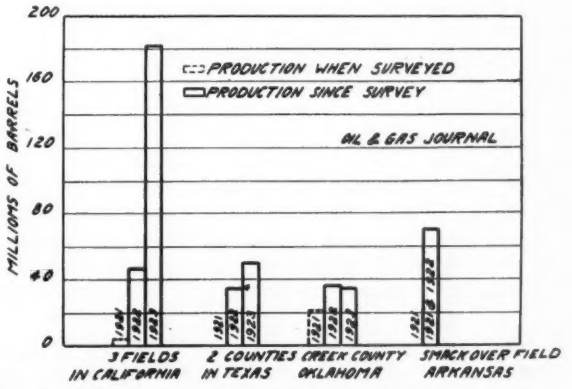


FIG. 3. PRODUCTION OF CRUDE OIL FROM FIELDS NEW OR UNDISCOVERED AT THE TIME OF THE 1922 SURVEY

estimated that 80 per cent of the original oil content remains in the ground when the wells are abandoned.

COAL BY-PRODUCTS AND SHALE OIL

Modern, perfected scientific methods of carbonization will give, on the average, from one ton of coal, 3 gal. of motor spirit, 18 gal. of crude, dry, paraffinoid oils, of which at least 50 per cent is available for Diesel engines, and other by-products, leaving 1400 lb. as residual smokeless-burning coke. This method is being used extensively in Europe, particularly by Germany, for the production of tar oils for use in Diesel engine plants. If all the soft coal mined annually in America were processed, enough

* From a paper delivered before the New England Water Works Association at Boston, Mass.

† Chief Engineer, Beloit Works, Fairbanks, Morse & Co.

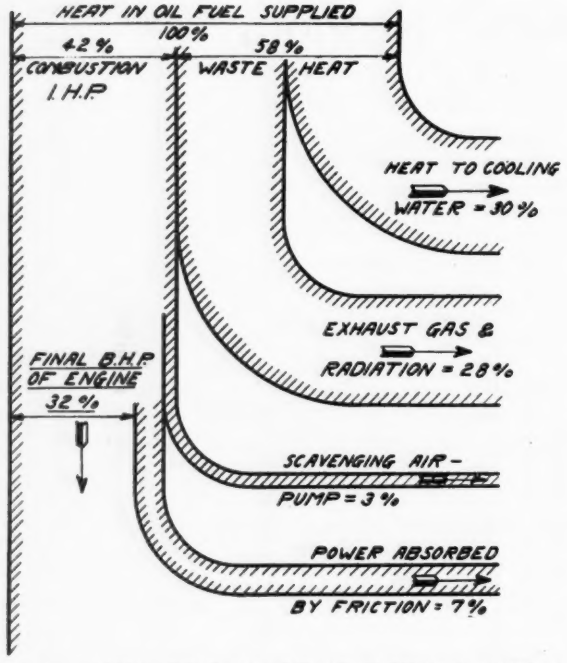


FIG. 4. TYPICAL HEAT BALANCE OF FAIRBANKS, MORSE & CO., TYPE Y DIESEL ENGINE

fuel oil would be available to take care of the present consumption.

Oil shale deposits of our western states are the most important future source of supply of oil in this country. Shale oil is similar to petroleum and can be made to yield an analogous range of products such as fuel oil, gasoline, lubricating oils and various by-products. Estimates of our shale oil resources indicate that the deposits of this country form a potential supply for oil greater than the total production of petroleum to date.

Results obtained in foreign countries and tests made in this country indicate that shale oil is commercially feasible in the U. S. and is only being held back by the present flush production of petroleum and the resulting low price. At Elko, Nev., the first shale oil plant in the U. S. is operating on a commercial basis, with a daily production of 100 T. of shale which yields about 1 bbl. of oil to the ton. Results secured have been so satisfactory that the owners have ordered the construction of four more plants in that locality.

At least two other plants are now operating, with others under construction. Their importance lies, not in the quantity of oil produced, which totals only a few hundred barrels a day, but in establishing the fact that shale oil can be produced at a cost that permits of its sale in competition with well oil, even during this period of flush production.

Diesel Engine Economy

It is not intended to recommend the adoption of oil engines wherever power is required, but to study the field and the oil engine plant from the economic standpoint as well as the technical. Figure 4 shows the heat balance of a most modern Diesel engine, indicating a brake thermal efficiency of 32 per cent. This efficiency is permanent and obtainable in every-day operation.

Factors governing the selection of machinery for a power plant or pumping plant, briefly expressed, are: First cost of buildings and machinery; life, reliability and maintenance; operating cost for wages, supplies, fuel and lubrication; load factor; dependability.

Comparative Costs for Pumping

In order to get disinterested comparison of the costs of pumping water with steam power, electric power and Diesel engines, Maury & Gordon, consulting engineers of Chicago, were asked to prepare a general report on the subject, which they did on condition that it contain no reference to product of any manufacturer or any type of machinery, that data were to be secured by them from their own records, from recent quotations by various makers of machinery and from reliable records of performance in existing plants.

Plants were considered for cities of 100,000, 50,000, and 10,000 inhabitants, requiring 120 gal. per capita daily consumption, or totals of 12,000,000, 6,000,000, and 1,200,000 gal. a day. Necessary reserve units were included to provide for Underwriters' requirements for fire protection and for breakdowns. Prices for coal, oil and labor are current figures for similar localities in towns of the populations as specified. Rates for electric current are from existing schedules and provide for a sliding scale of demand and energy charges. These give 1.4c for the 12,000,000-gal. plant, 1.51c for the 6,000,000-gal. plant and 2.1c

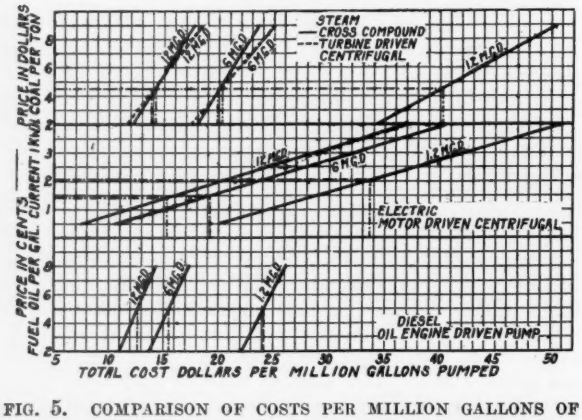

PRICE IN CENTS — FUEL OIL PER GAL. CURRENT IN $ COAL PER TON
STEAM
CROSS COMPOUND
TURBINE DRIVEN CENTRIFUGAL
ELECTRIC MOTOR DRIVEN CENTRIFUGAL
DIESEL OIL ENGINE DRIVEN PUMP
TOTAL COST DOLLARS PER MILLION GALLONS PUMPED

FIG. 5. COMPARISON OF COSTS PER MILLION GALLONS OF WATER PUMPED FOR STEAM-DRIVEN, MOTOR-DRIVEN AND DIESEL ENGINE-DRIVEN PLANTS OF THREE CAPACITIES

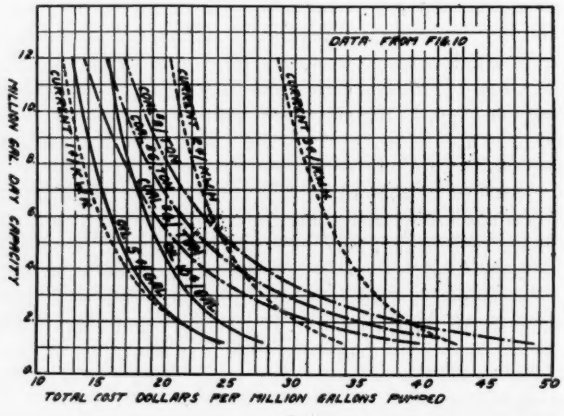


FIG. 6. COSTS FOR STEAM, ELECTRIC AND OIL ENGINE PUMPING AT VARIOUS COSTS FOR FUEL AND CURRENT

TABLE I. FIRST COST OF PUMPING EQUIPMENT, AUXILIARIES AND BUILDINGS

12,000,000 Gal. per day				
TYPES OF PUMPS	A	B	C	D
(A) 3-12 M. G. D. Cross Comp. Hor. Cr. & Fly Wheel Cond.	$160,000			
(B) 3-12 M. G. D. St. Turb. Driven Centrifugals		96,000		
(C) 3-12 M. G. D. Mot. Driven Centrifugals			24,000	
(D) 3-12 M. G. D. Hor. Triplex geared to Diesels				210,000
Foundations:	3,150	1,800	900	6,750
Boilers:				
Stokers	33,600	38,500		
Breeching				
Feed Pumps	11,000	11,000		
Foundations				
Settings				
Accessories				
Pipings & Fittings:			10,000	
Duplicate Line, Transformers & Wiring:				
Piping for Cooling Water & Oil:				1,000
Side Track:	2,000	2,000		2,000
Crane:	7,000	6,100	4,800	7,000
Fuel Storage:	2,000	2,000		2,000
Building:				
(A) 417,562 cu. ft. @ $.27	112,742			
(B) 394,568 cu. ft. @ $.27		106,533		
(C) 118,800 cu. ft. @ $.30			35,640	
(D) 324,576 cu. ft. @ $.28				90,881
Concrete Stack:	5,000	5,000		
TOTAL	$336,492	$268,933	75,340	319,631

6,000,000 Gal. per day				
TYPES OF PUMPS	A	B	C	D
(A) 2-6 M. G. D. Cross Comp. Hor. Cr. & Fly Wheel, Cond.	$72,000			
1-8 M. G. D. Cross Comp. Hor.	45,000			
(B) 2-6 M. G. D. St. Turb Driven Centrifugals		44,000		
1-8 M. G. D. St. Turb. Driven Centrifugals		26,000		
(C) 2-6 M. G. D. Mot. Driven Centrifugals			8,000	
2-4 M. G. D. Gas Engine Driv. Centrifugals			13,000	
(D) 2-6 M. G. D. Oil Engine Driven Duplex or Triplex Pumps				90,000
2-4 M. G. D. Gas Engine Driv. Centrifugals				13,000
Foundations:	2,700	1,200	1,100	3,450
Boilers:				
Stokers				
Breeching				
Feed Pumps				
Foundations				
Settings				
Accessories	23,200	25,650		
Piping & Fittings:	6,000	6,000		
Piping for Cooling Water & Oil:				750
Side Track:	2,000	2,000		2,000
Crane:	6,000	5,800	4,800	5,200
Fuel Storage:	1,600	1,600	400	2,000
Building:				
(A) 363,347 cu. ft. @ $.27	98,104			
(B) 358,892 cu. ft. @ $.27		96,901		
(C) 126,000 cu. ft. @ $.30			37,800	
(D) 216,000 cu. ft. @ $.29				62,640
Concrete Stack:	4,000	4,000		
TOTAL	$260,604	213,151	65,000	179,040

1,200,000 Gal. per Day			
TYPES OF PUMPS	A	C	D
(A) 2-1.2 M. G. D. Cross Comp. Hor. Cr. & Fly Wheel non Cond.	$7,000		
1-3.0 M. G. D. Gas Engine Driven Centrif.	5,000		
(C) 2-1.2 M. G. D. Mot. Driven Centrifugals		3,000	
1-3.0 M. G. D. Gas Engine Driv. Centrifugals		5,000	
(D) 2-1.2 M. G. D. Oil Engine Driven Triplex Pumps			20,400
1-3 M. G. D. Gas. Eng. Driv. Centrifugal			5,000
Foundations:	650	350	1,450
Boilers:			
Stokers			
Breeching			
Feed Pumps			
Foundations			
Settings			
Accessories:	7,000		
Piping & Fittings:	1,000		
Piping for Cooling Water & Oil:			300
Side Track:	2,000		2,000
Crane	2,500	1,800	2,400
Fuel Storage:	1,000	400	1,600
Building:			
(A) 80,220 cu. ft. @ $.29	23,264		
(C) 22,848 cu. ft. @ $.40		9,139	
(D) 38,640 cu. ft. @ $.35			13,524
Stack:	1,500		
TOTAL	$ 50,914	19,589	46,674

for the 1,200,000-gal. plant. Charges for supplies, repairs, interest and depreciation are based on experience of Maury & Gordon and other available records and information.

Tables I and II give comparative first costs and operating costs, while Figs. 5 and 6 give curves of costs per 1,000,000 gal. pumped for the three types of plants in three sizes and for various costs of coal, oil and electric current. The curves of Fig. 5 include all operating costs and fixed charges.

Actual Costs of Diesel Plant Operation

For small municipal plants, it is difficult to secure reliable operating figures because, in many cases, complete operating records are not kept. As a result of inves-

TABLE II. OPERATING EXPENSES AND FIXED CHARGES FOR DIFFERENT TYPES OF EQUIPMENT

12,000,000 Gal. per Day				
	Types			
	A	B	C	D
Labor:				
Ch. Engr.	$3000	$3000	$3000	$3000
Asst. " @$2100 ea.	6300	6300	6300	10500
Firemen @$1800 ea.	10800	10800		
Fuel (12 M. G. D.)				
(A) 3478 t. coal 145,000,000 ft. lb. duty. 7 lb. evap'n @ $4.50 per t.	15651			
(B) 4188 t. coal 112,000,000 ft. lb. duty. 7 lb. evap'n @ $4.50 per t.		18846		
(C) 3,686,208 kw-hr. 67% overall eff. @ 1.4¢ kw-hr.			51607	
(D) 261,905 gal. oil @ lb. per B. H. P. hr. 85% pump eff. @ 5¢ gal.				13095
Oil and Waste:	350	600	200	1800
Maintenance & Repairs:				
Mach. & Equip:				
(A) $204,600 @ 1.5%	3069			
(B) 145,500 @ 1.7%		2473		
(C) 34,000 @ 1.5%			510	
(D) 211,000 @ 1.9%				4009
Track, Crane, Coal & Fuel Storage:				
(A) $131,892 @ 0.5%	659			
(B) 123,433 @ 0.5%		617		
(C) 41,340 @ 0.5%			207	
(D) 108,631 @ 0.5%				543
SUB TOTAL	$39829	$42636	$61824	$32947
Interest & Dep.*				
Mach. & Equip:				
(A) $204,600-6.9%	14117			
(B) 145,500-8.36%		12164		
(C) 34,000-7.50%			2550	
(D) 211,000-8. %				16980
Buildings:				
(A) $131,892-5.8%	7650			
(B) 123,433-5.8%		7159		
(C) 41,340-5.8%			2398	
(D) 108,631-5.8%				6301
SUB TOTAL	$21767	$19323	$4948	$23281
TOTAL	$61596	$61959	$66772	$56228

6,000,000 Gal. per Day				
	Types			
	A	B	C	D
Labor:				
Ch. Engr.	$2700	$2700	$2700	$2700
Asst. " @$2000 ea.	6000	6000	6000	8000
Firemen @$1700 ea.	6800	6800		
Fuel (6 M. G. D.)				
(A) 1831 t. coal 138,000,000 ft. lb. duty. 6⅔ lb. evapor'n @ $4.50 per t.	8240			
(B) 2408 t. coal 105,000,000 ft. lb. duty. 6⅔ lb. evap'n @ $4.50 per t.		10836		
(C) 1,900,044 kw-hr. 65% overall eff. @ 1.5¢ kw-hr.			28690	
(D) 136,188 gal. oil .52 lb. per B.H.P. hr. 85% pump eff. @ 5¢ gal.				6809
Oil and Waste:	250	450	200	1250
Maintenance & Repairs:				
Mach. & Equip:				
(A) $146,200 @ 1.5%	2193			
(B) 101,650 @ 1.7%		1728		
(C) 21,000 @ 1.6%			336	
(D) 103,750 @ 2.0%				2075
Track, Crane, Coal & Fuel Storage:				
(A) $114,404 @ 0.5%	572			
(B) 111,501 @ 0.5%		558		
(C) 44,100 @ 0.5%			221	
(D) 75,290 @ 0.5%				376
SUB TOTAL	$26755	$25072	$38147	$21210
Interest & Dep.				
Mach. & Equip:				
(A) $146,200-6.9%	10088			
(B) 101,650-8.36%		8498		
(C) 21,000-7.8%			1638	
(D) 103,750-8.2%				8508
Buildings:				
(A) $114,404-5.8%	6635			
(B) 111,501-5.8%		6467		
(C) 44,100-5.8%			2558	
(D) 75,290-5.8%				4367
SUB TOTAL	$16724	$14965	$4196	$12875
TOTAL	$43478	$40037	$42343	$34085

1,200,000 Gal. per day			
	Types		
	A	C	D
Labor:			
Ch. Engineer	$2100	$2100	$2100
Asst. " @$1620 ea.	3240	3240	1620
Firemen	4200		
Helper			1200
Fuel (1.2 M. G. D.)			
(A) 993 t. coal 60,000,000 ft. lb. duty. 5⅓ lb. evap'n. @ $4.50 per ton.	4468		
(C) 392,098 kw-hr 63% overall eff. @ 2.1¢ kw-hr.		8234	
(D) 29,50⅔ gal. oil @ .55 lb. per BHP 83% pump eff. @ 5¢ gal.			1475
Oil & Waste:	100	75	250
Maintenance & Repairs:			
Mach. & Equip:			
(A) $20,000 @ 1.5%	300		
(C) 8,000 @ 1.6%		128	
(D) 25,700 @ 2.0%			514
Track, Crane, Coal & Fuel Storage:			
(A) $30,914 @ 0.5%	155		
(C) 11,689 @ 0.5%		58	
(D) 20,974 @ 0.5%			105
SUB TOTAL	$14563	$13835	$7964
Interest & Dep.*			
Mach. & Equipment:			
(A) $20,000-6.9%	1380		
(C) 8,000-7.8%		624	
(D) 25,700-8.2%			2107
Buildings:			
(A) $30.914-5.8%	1793		
(C) 11,689-5.8%		678	
(D) 20,974-5.8%			1216
SUB TOTAL	$3173	$1302	$3323
TOTAL	$17736	$15137	$10587

*Interest is at 5%. Depreciation is, for A, 1.9%; for B, 3.36%; for C, 2.5% on the largest plant, 3.2% on the others; for buildings 0.8% on all plants.

TABLE III. EQUIPMENT AND SERVICE RECORD OF DIESEL MUNICIPAL PLANTS

No. of Plant	Location	Service	Equipment Engine	Elec., etc.	Total hp.	Daily Service	Yrly. Eng. hrs. total	Yrs. Service	Longest Run Hr.	Load Factor Running time	Load Factor Yearly
1.	New England, N. D.	Elec. lt. & Power	1-50 hp. D.*	40 kv. a. 2300 v.	150	24 hr.	7552	1½	90	37.5%	15%
			1-100 hp. D.	75 kv. a. 2300 v.							
2.	Eureka, So. Dak.	Cent. Sta.	1-100 hp. D.	72 kw. "							
			1-50 hp. B.*	30 kw. "							
			1-25 hp. B	20 kw. "	175	24 "	11315	8	144	42%	18%
3.	Pender, Nebr.	Elec. lt. & Power	1-100 hp. D.	75 kv. a. "							
			1-150 hp. D.	125 kv. a. "	250	24 "	--	1	1350		
4.	Oakland, Nebr.	Pumping	1-50 hp. B.		50	10 "	3650	2	16		
5.	Storm Lake, Ia.	Pumping	1-37½ hp. B.		37½	14 "	4750	3	18		
6.	Perry, Ia.	Pumping	2-100 hp. D.	60 kw. 230 v.							
			3-25 hp.D.		75	24 "	8800	1	85	82%	41%
7.	Bancroft, Nebr.	Lt. & Power	2-50 hp. B.	37½ kv.a. 2300 v.	100	24 "	8395	6	21	48%	23%
8.	Emerson, Nebr.	Lt. & Power	1-37½ hp. B.	25 kw. "							
			1-50 hp. B.	37½ kw. "							
			1-150 hp. D.	125 kv.a. "	237½	24 "	10030	5	60		
9.	Natchitoches, La.	Pumping	2-150 hp. D.	125 kv.a. "	300	24 "	8459	4	144		
10.	Gallipolis, O.	Pumping	1-100 hp. B.		100	12 "	4380	1½	144		
11.	Watsonville, Cal.	Ice & Cold Storage	1-50 hp. B.		50	24 "	8010	10	2324		
12.	San Ardo, Cal.	Irrigation	1-100 hp. B.		100			4	366		
13.	Quincy, Mich.	Lt. & Power & Pumping	1-100 hp. D.	75 kv.a. 1150 v.	300	24 "	8760	4	656		
			1-200 hp. D.	170 kv.a. "							
14.	Santa Cruz, Cal.	Pumping	1-100 hp. B.		250	24 "	6200	8	1440	52%	36%
			1-150 hp. B.								
15.	Madil, Okla.	Pumping	1-75 hp. D.		150	8 "	2920	2	18		
			1-75 hp. D.								
16.	Fayetteville, Ark.	Water Improvement	1-150 hp. Cl.		150	24 "	6570	1½	18		
17.	Strawn, Tex.	Lt. & Power	2-50 hp. D.	40 kv.a.	250	24 "	14620	10	18		
			1-150 hp. D.	125 kv.a.							
18.	Roodhouse, Ill.	Water	1-75 hp. D.		75	--	--	3	16	58%	37%
19.	Terrill, Tex.	Lt. & Power	3-200 hp. D.	170 kv.a.	900	24 "	--	2	48		
			1-300 hp. D.	250 kv.a.							
20.	Garland, Tex.	Lt. & Power	2-100 hp. D.	75 kv.a.	350	24 "	--	1	48		36%
			1-150 hp. D.	125 kv.a.							
21.	Nicholasville, Ky.	Pumping	1-100 hp. D.		100	8 "	2920	1	492		
22.	Stonewall, Okla.	Elec. Lt.	2-50 hp. D.	40 kv.a. 2300 v.	100	24 "	10220	6	24		
23.	Vinalhaven, Me.	Elec. Lt. & Pr.	1-50 hp. D.	32 kw.	75	10 "	4350	6	164		
			1-25 hp. B.	16 kw.							
24.	Covington, Tenn.	Elec. Lt. & Pr.	1-100 hp. D.	75 kv.a. "	600	24 "	5760	1	120		
			1-200 hp.	170 kv.a. "							
			1-300 hp.	250 kv.a. "							
25.	Charleston, Miss.	Water & Lt.	1-100 hp. D.	75 kv.a.	300	24 "	12000	1	2160	57%	21%
			1-200 hp.	170 kv.a.							
26.	Crystal Falls, Tex.	Water	1-50 hp. B.		150	24 "	5923	4	528		
			1-100 hp. D.								
27.	Newton, Miss.	Lt. & Water	1-50 hp. D.	40 kv.a.	300	24 "	12720	4	3360	38%	23%
			1-100 hp. D.	75 kv.a.							
			1-150 hp. D.	125 kv.a.				2	1176		
28.	Woodsfield, O.	Lt. & Power	2-200 hp. D.	170 kv.a. "					216		
29.	New Philadelphia, O.	Coal	1-100 hp. B.	80 kw. 250 v.							

Note:* D means direct connected; B means belted

tigation, however, we are able to show some detailed costs on the operation of twenty-nine municipal pumping and power plants, perhaps not the best that could be secured, but probably representing the average of practice.

Table III shows the principal equipment which is contained in these twenty-nine stations and their operating records. It will be noted that fourteen are operated on electric light and power service, while the rest are classed as pumping stations. Table IV shows fixed charges and operating costs.

Records on oil used show that the average cost of fuel in all of the plants under consideration was 5.4c per gal. or $2.16 per bbl. and the average cost of lubricating oil was 55.9c per gal. during the year 1923.

Operating labor cost is partly dependent on the yearly load factor of the plant and partly on the number of units which are installed. It naturally follows that a plant which operates 16 hr. out of the day will require more operating expense than one which operates 8 hr. a day and it also follows that a plant containing three or four units will require more care and, therefore, more expense than a single-unit plant.

TABLE IV. OPERATING COSTS AND FIXED CHARGES OF DIESEL MUNICIPAL PLANTS

No. of Plant	Total Invest.	Fixed Charges Total	Fixed Charges Units	Yearly kw. hr.	Attendants	Labor Cost	Operating Cost Total	Operating Cost Unit	Total Unit Cost	Fuel & Lubr. Oil. Unit cost	Eng. Reprs. Total Cost
1.	$19800	$1980	$0.0174	113605	2	$3000	4929	$0.0434	$0.0608	$0.016	--
2.	36300	3630	0.0220	165050	3	3900	6787	0.0411	0.0631	0.0147	$2506.00
3.					3	4800					--
4.					1	2160					0.84
5.					1	1620					--
6.	30000	3000	0.0070	430000	3	3440	7320	0.0170	0.0240	0.0066	--
7.	18200	1820	0.0152	120000	2	2400	4080	0.0340	0.0490	0.0140	1007.68
8.					3	4320					980.88
9.					3	4320					150.00
10.					1	1900					65.00
11.					1*	1200					265.00
12.											--
13.	41000	4100	0.0102	403000	3	4440	8497	0.0210	0.0312	0.0094	785.00
14.					3	2270					368.00
15.					1	1200					51.51
16.					2	1740					--
17.	34400	3440	0.0071	481800	3	4800	10309	0.0214	0.0285	0.0079	6293.00**
18.					2	3000					249.03
19.	74400	7440	0.0058	1271400	4	5760	15224	0.0120	0.0178	0.0074	605.15
20.					2	2820					--
21.					1	900					--
22.					2	2400					750.00
23.					2	2500					1554.12
24.	92000	9200	0.0141	650000	3	2310	10236	0.0157	0.0298	0.008	--
25.					2	2010					21.65
26.					2	3206					527.67
27.	54000	5400	0.0148	365000	2	2300	5648	0.0155	0.0303	0.009	308.46
28.											414.90
29.											54.04

*One man on each shift operates ice plant.
** Crankshaft

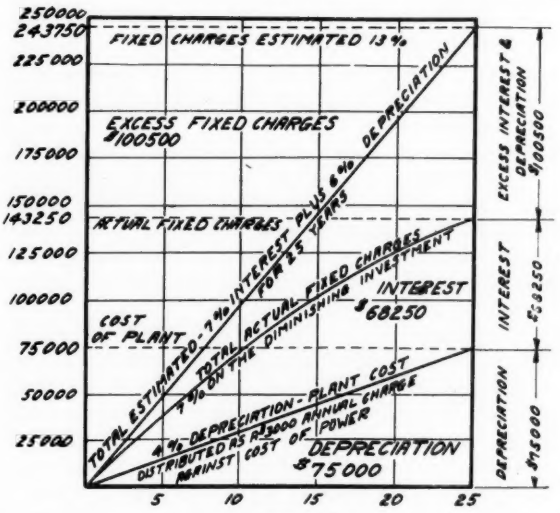


FIG. 7. FIXED CHARGES ON $75,000 DIESEL ENGINE PLANT WITH USUAL METHOD OF ESTIMATING AND WITH SINKING FUND METHOD

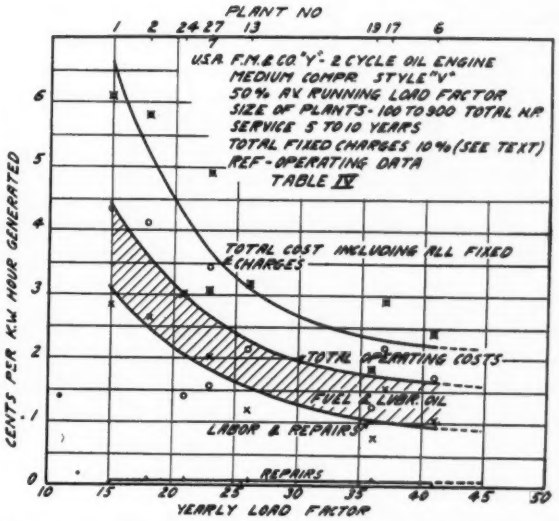

PLANT NO
1 2 24 27 13 19 17 6
U.S.A. F.M.E. CO. "Y"- 2 CYCLE OIL ENGINE
MEDIUM COMPR. STYLE "V"
50% AV. RUNNING LOAD FACTOR
SIZE OF PLANTS- 100 TO 900 TOTAL H.P.
SERVICE 5 TO 10 YEARS
TOTAL FIXED CHARGES 10% (SEE TEXT)
REF.-OPERATING DATA
TABLE IV
TOTAL COST INCLUDING ALL FIXED & CHARGES
TOTAL OPERATING COSTS
FUEL & LUBR. OIL
LABOR & REPAIRS
REPAIRS
CENTS PER K.W. HOUR GENERATED
YEARLY LOAD FACTOR
10 15 20 25 30 35 40 45 50

FIG. 8. DETAILS OF COST PER KW-HR. FOR DIESEL ENGINE PLANTS AT VARIOUS LOAD FACTORS

Eight single-unit plants show an average labor cost of $1565 a year; twelve two-unit plants averaged $2999 and six three-unit plants averaged $3408. Only one four-unit plant is operated with labor cost of $5760. The average yearly cost per man is approximately $1500 a year. Labor costs depend somewhat on location, hence, there will be some variation in different plants, but it would hardly be possible to reduce any of these labor charges, as in many instances the single-unit plants are operated by one man and even the three-unit plants require only three men when operated on a 24-hr. basis, or one man per shift.

On account of its fairly high first cost, it has been claimed that the fixed charges on a Diesel engine are necessarily extremely high. A good oil engine maintained in regard to the wearing elements will last indefinitely. Experience indicates that the parts which require care and maintenance are common to all prime movers. Records available through the British Diesel Engine Users' Association and American records obtained during the last 20 yr. indicate that the useful life of a modern Diesel engine can with the utmost safety and conservatism be set at 25 yr. While the obsolescence figure in depreciation of the Diesel engine is negligible, it is essential that the amount of actual depreciation be carefully determined.

Figure 7 shows that the total yearly interest on the cash outlay becomes less each year as the amount originally invested is reduced by the yearly depreciation, hence, fixed-charge percentage rates cannot justly be assumed. Arbitrary rates of fixed charges including interest, depreciation and insurance have often been set as high as 13 to 15 per cent.

A suggested method in determining the fixed charges against the investment is to use a liberal interest rate; then, instead of a fixed depreciation rate use such percentage of the initial investment as, when set aside as a sinking fund with interest compounded annually, will aggregate the original cost investment at the end of the estimated life of the equipment. If 5 per cent be used as interest rate, the percentage for depreciation sinking fund will be, for 20 yr. life, 3.02 per cent; for 25 yr. life, 2.1 per cent; for 30 yr. life, 1.5 per cent. At 6 per cent interest, the corresponding rates will be, for 20 yr. life, 2.72; for 25 yr., 1.82; for 30 yr., 1.26. At 7 per cent interest, rates will be for 20 yr., 2.44; for 25 yr., 1.58; for

TABLE V. COMPARATIVE COSTS OF OIL ENGINE, STEAM AND MOTOR-DRIVEN PUMPING PLANTS

No. or location	No. of Pumps	1,000,000 Gal. Pumped Daily	Static Head ft.	Operating Costs Except Fuel & Lub. Oil Total	Operating Costs Except Fuel & Lub. Oil per Mil. Gal.	Fuel & Lub Oil Total	Fuel & Lub Oil per Mil.Gal. Actual	Fuel & Lub Oil per Mil.Gal. Corr. for 150 ft. head	Total Cost per Mil. Gal. Actual	Total Cost per Mil. Gal. Corr. for 150 ft. head	Prices Fuel oil per gal.
5	2	142	150	$1805	$12.72	$1505	$10.60	$11.12	$23.32	$23.84	11.9¢
10	1	163.3	322	2115	12.92	1532	9.38	4.37	22.30	17.29	6.47¢
15	2	87.6	402	1260	14.38	619	7.07	2.64	21.45	17.02	4.0¢
16	1	222	402	2040	9.20	2568	11.55	4.32	20.75	13.52	6.02¢
26	2	262.1	200	4046	15.41	1457	5.56	4.17	20.97	19.58	3.57¢
Steam Pumping Plant											Coal per ton
Marinette	4	617	150	4142	6.70	15806	25.60	25.60	32.30	32.30	$6.72
La Crosse	8	1213	240	18780	15.45	19419	16.00	10.00	31.45	25.45	6.89
Berlin	2	77.4	135	4066	52.70	2093	27.10	30.50	79.80	83.20	7.00
Washburn	2	155.8	250	2840	18.25	6186	39.75	23.80	58.00	42.05	9.33
Janesville	4	589	175	6760	11.45	7405	12.55	10.75	24.00	22.20	6.04
Kenosha	5	1670	162	17491	10.45	19816	11.85	10.97	22.30	21.42	7.60
So. Milwaukee	6	317	210	11536	36.50	11847	37.40	26.70	73.90	63.20	7.60
Motor Driven Pumping Plant Current Costs											Current per kw-hr
Menominee	2	170	240	3361	19.80	5633	33.10	20.70	52.90	40.50	1.25¢
Delavan	3	244.3	185	3560	145.80	1378	56.60	68.00	202.40	213.80	3.0¢
Columbus	2	466.5	135	767	16.50	1573	34.80	38.70	51.30	55.20	3.5¢
Castleton	1	146.7	223	1374	93.50	1533	104.20	70.40	197.70	163.90	4.5¢
Neenah	3	177	110	3642	20.60	8246	46.50	39.40	67.10	60.00	
Wisc. Rapids	4	214	195	2619	12.20	5034	23.50	18.05	35.70	30.25	2.44¢
Chippewa Falls	4	371.6	185	2471	6.65	6475	17.40	14.10	24.05	20.75	1.44¢
Lake Geneva	4	608.7	186	3531	58.00	4132	67.80	54.70	125.80	102.70	3.0¢
Stoughton	3	150.4	185	2904	19.35	3190	21.20	17.20	40.55	36.55	2.0¢
Waukesha	8	536.6	150	7133	13.28	13494	34.50	34.50	47.78	47.78	2.39¢

Note: Motor and steam plant costs from Railroad Commission, State of Wisconsin

30 yr., 1.06. On this basis, if 7 per cent and 25 yr. life be taken, interest charges will be 7 per cent on the first cost, depreciation sinking fund, 1.58 per cent and insurance say 1.5 per cent or, approximately 10 per cent on the first cost of the engine as a yearly fixed charge.

Figure 8 shows detailed unit costs, taken from the tables, of electric power plants having approximately 50 per cent running load factor. It is interesting to note the low repair item which is distinctive of the two-cycle, simple oil engine and the uniformity of fuel and lubricating oil costs irrespective of load factor.

In a few plants, charges for extra labor have been reported; in No. 8, $40 over a 5-yr. period; in No. 10, $50 for 1½ yr.; in No. 15, $50 for 4 yr.; and in No. 28, $523.98 for 2 yr. For such plants as gave available figures, repair cost per unit of output has been computed as follows: For No. 2, $0.000,24; for No. 7, $0.000,16; for No. 13, $0.0005; for No. 17, $0.0012; for No. 19, $0.000,24; for No. 27, $0.000,27.

Columns 6 to 9 of Table III list some significant data on the subject of reliability.

Operating costs for steam and motor-driven pumping plants, shown in Table V for comparison with Diesel plants from Table IV, were taken from public records in the office of the Railroad Commission of the State of Wisconsin at Madison. All of the plants are operating in municipal service, have about the same yearly load factor and work under the same general service conditions.

Measurement of Coefficients of Viscosity

PROCESSES now employed in industry for the determination of the viscosity of a liquid are empirical and vary in different countries, so that there exists no correspondence between the diverse scales of viscosity such as Engler, Redwood, Sayboldt, Barbey. Consequently, the French Society of Industrial Physics has considered this matter worthy of a place on its program of studies and has commissioned M. Baume to study the problem. This study appears in Chaleur et Industrie for December.

Rate of movement of a liquid flowing from a capillary tube is given by the formula of Poiseuille: $v = \frac{3.1416\ pr^4\ t}{8Cl}$, in which v is the volume of the liquid flowing under a pressure p during a time t from a capillary tube of length l; C represents a factor which depends, other things being equal, upon the nature of the liquid and its temperature. This factor is the coefficient of internal friction, or the coefficient of viscosity.

If the liquid flows under the influence of its own weight the quantity p must be replaced by the product gdh, g being the acceleration due to the weight, d the density of the liquid at the temperature of the experiment and h the height of fall. We have then for the coefficient of viscosity, expressed in dynes per square centimeter, in the C.G.S. system: $C = \frac{3.1416\ gdhr^4\ t}{8vl}$, a formula which serves for the experimental determination of the coefficient of viscosity of liquids. Thus the measurements of these coefficients in absolute value, based on the formula of Poiseuille, would be long and difficult.

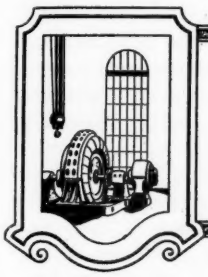
Practically, instead of measuring the different terms of this formula, the relative viscosity of liquids is found by means of the times which different liquids require to flow through the same tube under identical conditions. The factor $\frac{3.1416\ ghr^4}{8vl} = k$ is then a constant of the apparatus used, this constant being determined by the aid of a liquid of which the absolute viscosity is known; for example, benzine, water, or aqueous solutions of sacharose of different concentrations, by means of which systems more or less viscous are easily arranged.

Viscosimeters which are now employed for the experimental determination of the viscosity of liquids are those of Redwood in England, Sayboldt in the United States, Engler in Germany, and the ixometer of Barbey in France, for the measurement of the fluidity, which is the inverse of the viscosity. These appliances have the inconvenience of requiring a considerable quantity of liquid, which is a serious inconvenience because the variation of the coefficient of viscosity in function of the temperature is often rapid and also because the calorific conductibility of liquids and of oils in particular, is feeble. It is therefore desirable in order to have rapid and accurate measurements, first, to operate with as small volumes as possible, as this permits the rapid heating of the liquid to be tested, and secondly, to employ a thermostat graduated with great precision, containing a reservoir for the liquid before flowing, the capillary tube and a chamber for the liquid after flowing.

M. Baume's instrument is based on the same principle as that of Ostwald, but is less fragile and more easily handled. It consists essentially of three parts: a thermostatic jacket, made of a special glass made in France by the Societe Pyrex, and its refrigerant, which is a jacket containing a liquid maintaining a constant temperature. For the establishment of a viscosity curve M. Baume recommends operating at the following temperatures: 0 deg. C., melting ice; 15 deg. C., jacket fed with circulation of water; 35.3 deg. C, vapor fed by ether; 56.5, 80.3, 100, 132, and 156 deg. C., which temperatures are given respectively by the vapors of acetone, benzene, water, chlorobenzene and bromobenzene.

A capillary tube is used, in which the liquid to be tested flows of its own weight. This is held in the tube by a rubber stopper, the other hole allowing the passage of a thermometer. A chronograph is used to show fifths of a second and indicating at least up to 30 min.

To make an experiment, the test tube is carefully cleaned with benzene, alcohol and ether and then dried. The thermostatic liquid is inserted into the jacket. A little mercury is placed at the bottom of the tube to assist the transmission of temperature changes. The capillary tube containing a small quantity of the oil to be tested, and the thermometer, are placed in the tube. The liquid in the outer tube is now made to boil, and when the temperature of the whole apparatus is constant a column of oil is forced above the mark on the capillary tube, by compressing the rubber bulb. This pressure being released, the time which the oil takes to fall over a given range is carefully noted by means of the chronometer. The absolute viscosity in dynes per square centimeter is given by the formula $V = kdt$; k being a constant of the instrument, d the density of the liquid, and t the time of flow in seconds and fractions of a second.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operation of Converting Apparatus---IX

FINAL CONSIDERATIONS. CHANGING THE FREQUENCY OF ALTERNATING CURRENTS. BY V. E. JOHNSON

IN CONCLUDING this series of articles on the general subject of converting apparatus, we will discuss briefly the methods of changing from one frequency to another. Many of the larger power systems operate simultaneously at 25 and 60 cycles. In order that the current may be available at either frequency it is necessary that equipment be provided for changing from one to the other.

FREQUENCY CHANGERS

An ordinary wound rotor motor may be used as a frequency changer by merely providing means for externally controlling the speed of its rotor. In order to make a commercial application of such a machine it is necessary to have the rotor wound for a suitable and convenient voltage.

Such apparatus is seldom used except for laboratory and other special applications. The principle involved is quite simple, and without going into details may be briefly outlined as follows:

If the rotor of a wound rotor motor having a three-phase primary and a three-phase secondary be locked so that it cannot rotate, the apparatus becomes essentially a three-phase transformer and current may be taken from the rings at the stator frequency. If on the other hand, the rotor revolves at synchronous speed, the frequency across its rings would be zero as there would be no voltage generated. If the rotor were compelled by external means to rotate at some intermediate speed the frequency of current taken from its rings would be between zero and full primary. If the rotor were rotated in a direction opposite normal, the result would be an increase in frequency.

By driving the rotor of an induction motor with a variable speed prime mover of some kind, or by a variable speed motor, a complete and unbroken chain of frequencies could be obtained, extending from zero at one end, to the mechanical limits of the machine at the other.

For commercial use frequency changers consist of motor generator sets, the generator being wound for the frequency desired and the motor being either synchronous or induction as the circumstances would require.

SYNCHRONOUS FREQUENCY CHANGERS

Synchronous frequency changers consisting of a synchronous motor driving a suitable a.c. generator are in very common use, and have several advantages over the induction motor sets. First of all the ratio between the frequencies is accurately obtained, which would not be the case with an induction motor due to its varying speed under various loads. Secondly, the synchronous motor can be used for power factor correction, while the induction motor would draw lagging currents from the line.

The common frequencies in use in this country are 60 and 25, and for that reason no others will be considered.

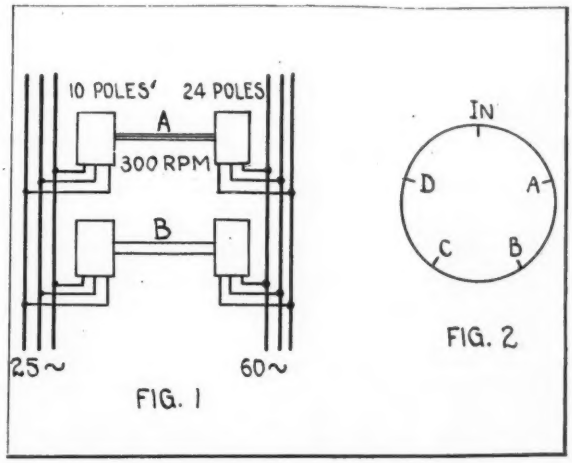


FIG. 1. TWO MOTOR GENERATOR SETS IN PARALLEL ON 25- AND 60-CYCLE BUSSES

FIG. 2. DIAGRAM OF SYNCHROSCOPE FACE TO SHOW SUCCESSIVE POSITIONS OF MOTOR

For 60-cycle current the following formula holds true:

Poles $\times$ r.p.m. equals 7200. From this it follows that

$$\text{Poles equals } \frac{7200}{\text{r.p.m.}} \text{ and also r.p.m. equals } \frac{7200}{\text{Poles}}$$

Example: A 10-pole synchronous motor will run $\frac{7200}{10}$ or 720 r.p.m.

Similarly for 25 cycles Poles $\times$ r.p.m. equals 3000 and the corresponding formulas for poles and r.p.m. may be deduced. Example: A 10-pole synchronous motor will run $\frac{3000}{10}$ or 300 r.p.m.

In order that a 25-cycle motor may drive a 60-cycle generator it is necessary to use a pole combination that will produce synchronous speed at both frequencies. The only practical one that can be used is one having 10 motor poles and 24 generator poles. This will run at 300 r.p.m. It would be possible to use a 20-pole motor and a 48-pole

generator, but the set so constructed would run at 150 r.p.m. which would be too expensive.

Parallel Operation of Synchronous Motor Generator Sets

A synchronous motor frequency changer set considered by itself presents no new problems. The motor is started as any similar motor is started, while the generator is in no way different from any other. When two sets are to be paralleled new problems arise, due to the fact that the motor and generator rotors are mechanically fixed in definite relative positions. As the speed necessarily must be the same, there is no way available for dividing the load unless some means be provided for varying the polar position of the generators with reference to each other.

Figure 1 shows two motor-generator sets having 10 motor and 24 generator poles, arranged to run from the same 25-cycle busses, and to feed into the same 60-cycle

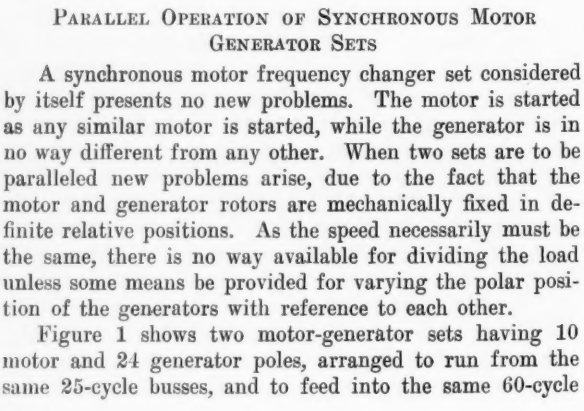


FIG. 3. DIAGRAM OF A SYNCHRONOUS MOTOR-GENERATOR SET

system. Either synchronous motor can be in step with the supply system in any one of five rotor positions, as it has five north poles and five south poles, and it matters not at all which one of these is in front of a given stator pole. If the field of the synchronous motor be reversed by the use of a double throw switch, the rotor will slip back one pole. This will change the polar position one pole span, and will also change the rotor position a like amount. If the field be reversed twice, the rotor will have moved through two pole spans, but the pole position will then be the same as at the start—as a north pole will again be in front of what was originally its mating stator coil.

Assume that A and B are in step on both ends. This means that mechanically a generator pole on A coincides with a pole on B. Reversing the motor field on B will cause it to drop back one pole span, and will cause the generator to drop back 2.4 pole spans. This is because 10 motor poles equals 24 generator poles. Two reversals will drop the generator a total of 4.8 pole spans. Three reversals will drop the generator a total of 7.2 pole spans. Four reversals will drop the generator a total of 9.6 pole spans. Five reversals will drop the generator a total of 12 pole spans.

At this point then the generator rotor has shifted one-half revolution and is again in step. Five more reversals would complete the revolution and in that position the poles of both motor and generator would occupy the relative positions they had at the start.

If the machine A is running and B is to be started, it is impossible to determine beforehand which of the five possible positions the motor rotor will assume. It may lock in step at a point where the generator poles also coincide, or it may come in at a point where the generator is a fraction of a pole span out, as shown in the previous paragraphs. Thus if the generator happens to be 2.4 poles ahead of its mate, one reversal of this motor field will drop it into step. Under any conditions it will not require more than 4 reversals unless for some reason the motor slips three poles and thus makes it necessary to repeat the operation.

Example: Assume that when B is started and its motor drops into step the synchroscope plugged across its generator terminals takes the position A in Fig. 2. One motor field reversal will swing the needle to B, a second reversal will bring it to C and so on—the fourth reversal bringing it to the top or "in" position where the oil switch can be closed.

If the mechanical relation between the two sets is not right, it will not be possible to find any point where the generator is in step, and in this case an adjustment must be made. Modern motor-generator sets have the stator of the motor mounted in a cradle so that it can be rotated through about 20 electrical degrees, and by using this device the two sets are brought into step. This setting need be made only once.

In actual practice the initial adjustment is usually made by the erecting engineer so that all the operator has to do is to reverse the motor field the proper number of times to bring about "in step" conditions on the generator. There will be considerable difficulty in doing this if the running set is heavily loaded so that its rotor "sags" behind. In fact, there are times when it is so far behind that the switching operation of paralleling produces a severe surge. There is no remedy for this except to watch the loads so that the new unit is brought in before the one in operation is too heavily loaded.

The generators must of course be phased out with lamps or other means as previously explained.

It sometimes happens that a motor-generator set forms the only interconnection between two large systems—one at 60 and the other at 25 cycles. If this set is small as compared to the smaller of the two systems, it will be unable to hold them together, and will trip out its breakers. There is no remedy for this except to provide additional capacity in frequency changers.

The division of load between two synchronous motor-generator sets is determined by the relative sag of their rotors as the output increases. The set which sags the least will take more than its share of the load. There is no adjustment which will take care of this. Moving the stators of the motors in their cradles will give adjustment at any selected point but not throughout the entire operating range. Some division may be obtained by adjusting the motor fields so as to change the sag.

Induction Motor Sets

For an induction motor set to change from 25 to 60 cycles, a 4-pole motor and 10-pole generator would be used. The motor would have a synchronous speed of 750 but the slip at load would bring this down to about 720 which would be right for the generator.

As the induction motor does not have definite polar positions, the process of synchronizing is simpler. After coming to full speed the incoming set will run above synchronism, so that to bring its generator in it is necessary to open the motor switch and catch the generator slowing

down past the point of synchronism. The motor switch is then closed.

If the induction motor is of the wound rotor type it will be possible to adjust the speed to obtain synchronism without opening the switch as indicated above.

Load division in an induction motor set can be controlled to some degree by varying the secondary resistance on phase wound motors, but on squirrel cage sets there is no adjustment possible. This is determined by the rotor design.

Field Adjustment

The generator fields should be adjusted in the same manner as any other alternating-current machine. This adjustment should be such as to secure the same power factor on all of the units. This can be determined either by a power factor indicator, or by noting the simultaneous readings of the ammeters and kilowattmeters.

The motor fields should be adjusted to secure the power factor correction desired. If unity power factor is wanted on the motors, the excitation should be varied until a point is found at which the line amperes are at a minimum.

Connections

Figure 3 shows in detail the connections for a synchronous motor-generator set showing the reversing switch in the field circuit of the motor. The starting is done by means of taps on auto transformers.

Instruction books which take up in detail the methods applying to the particular set being installed, are supplied by the manufacturers, who are always glad to lend assistance toward the solving of any difficulties that may arise. Much valuable time can be saved by carefully following the rules they give. The time to read the booklet or instruction tag is before starting construction. This will often eliminate costly mistakes.

Automatic Control for Substation Apparatus

A Discussion of Automatic Development Indicating the Necessity for Further Improvements Along Certain Lines

AUTOMATIC SUBSTATIONS have been in use for a number of years and many papers and reports covering their design and operations have been presented to the engineering profession. In almost every case, however, an attempt has been made to describe some particular installation. While such papers are of considerable value, it is not in all cases conducive to the most rapid progress. At the recent convention of the American Institute of Electrical Engineers at St. Louis, Walter H. Millan of the Union Electric Light & Power Co., of St. Louis, presented an extremely interesting paper on the subject of automatic control for substation apparatus in which he took the pessimistic side and presented much constructive criticism of the apparatus and systems available at present.

In general, said Mr. Millan, there are three classes of automatic operation, the first and most highly developed being the railway class. The next highest developed is the alternating current transforming and distributing substation. Here, as in the case of the railway station we have simplicity in that there are comparatively few functions the operation of which actually had to be automatized; the balance being only a matter of finding sufficient courage to close and lock the doors on equipment which had previously been operated with an attendant to watch it. We have had the automatic induction regulator with us for a good many years but always with someone close by, and while there is no reason why it should not be trusted to operate without a guardian, Mr. Millan admitted that he had spent some anxious hours during the first few weeks of such operation of equipment for which he was responsible.

The third and least developed class is that of supply stations to heavy Edison system networks where extremely low system resistance is encountered, close precision is called for in voltage regulation and an interruption to service is an unpardonable offense.

Mr. Millan did not attempt to discuss the weak points in the automatic railway station field since he stated his lack of experience in that field did not qualify him to do so. He therefore covered only the other two classes.

In the automatic stations in successful operation the good points are usually emphasized almost to the exclusion of others of equal importance; for example, we may find a station in which a great deal of effort has been concentrated on the automatic operation of its supply circuits to

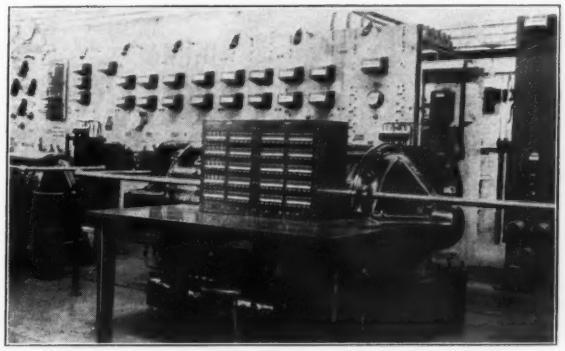


FIG. 1. DISTRIBUTOR SUPERVISORY EQUIPMENT, DESPATCHER'S KEY AND LAMP CABINET FOR CONTROLLING A.C. FEEDERS IN NEARBY SUBSTATIONS

prevent the possible loss of supply power due to failure of the supply circuit. This is accomplished by automatic transfer devices to keep power on the station bus as long as one of its supply circuits is alive. In the same station we may find only a single transformer unit supplying several important distribution feeders, no provision having been made to save the day if, by any chance the transformer should fail. Frequently this transformer depends on cooling water to carry it over the peak and we find that there is but one source of water supply or, if there are two, they are not automatically "changed" in event of failure. The conventional way to protect such a transformer against sustained overload is by means of the thermal relay, which is supposed to possess the same relative beating and radiating characteristics as the transformer, and so adjusted that full load amperes will enable the unit to stay on continuously but approximately 25 per cent in excess of this amount tripping the transformer off the line in 30 min. The exact principle of the operation of this device is usually only partially understood by the man

who actually locates it in the station and upon this point depends its real utility. To be consistent, this thermal relay must undergo exactly the same abuse and benefits regarding ventilation that the transformer suffers and it can be seen that, should the thermal relay be so located that its heat is dissipated by a draft of cold air from a ventilator or by conduction to a wall on which it may be mounted, it may fail to protect the transformer.

Manufacturers have recognized this liability and generally provide a thermostat submerged in the transformer oil, which trips off and locks out the transformer if the oil exceeds about 85 deg. C. This would probably save the transformer (but not the service) if the overload was approached slowly so that too great a drop in temperature between the "hot spot" and the oil was not in evidence; but, if a sudden overload appears after many hours of very light load, when the oil has cooled to an extremely low temperature, the oil with which the "hot oil" thermostat is in contact may be 50 deg. cooler than the "hot spot" and the thermostat useless should the thermal relay fail to function. The foregoing would indicate that we should attempt to develop a means of direct relaying from the actual, measured, hot spot temperature rather than to try, by means of a proportional auxiliary circuit, to imitate the performance of the transformer. Much may be said about thermostats. The average operating engineer notes in the specifications that a thermostat will stand guard over his transformer and he accepts this face value.

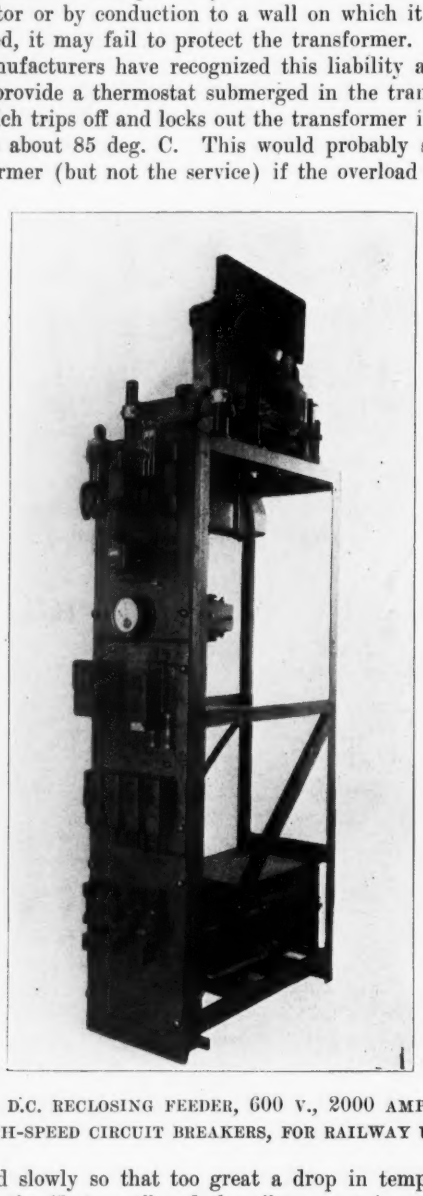


FIG. 2. D.C. RECLOSING FEEDER, 600 V., 2000 AMP. WITH HIGH-SPEED CIRCUIT BREAKERS, FOR RAILWAY USE

Without injustice to the electrical manufacturers, it may be said that we should not expect them to know as much about building these devices as do the manufacturers of heating and ventilating apparatus. Mr. Millan said he has found that these latter manufacturers possess equipment of this nature directly applicable to our needs which has been developed and in successful operation for years. When applied to transformers, thermostats are usually mounted on some projection on the head block or core, and this means that the transformer must be taken out of service and the oil lowered to get at them for test purposes. This problem was attacked in St. Louis some months ago and, as a result, thermostats made by a well-known manufacturer of heating apparatus who knew nothing of the possible applications to this field are being installed in many transformers there. These thermostats are no closer to the "hot spot" than their predecessors—(that being another problem)—but they may be removed and tested without even taking the transformer off the line. This applies to the "sealed" types of transformers as well as others.

Control of Cooling Water

Control of cooling water, so far as the thermostat is concerned, is also partly solved by the above but automatically operated water valves have not been given sufficient attention. Mr. Millan had experience with two types of valves which are furnished by the electrical manufacturers—the motor operated type and the type which is operated by the expansion and contraction of a gas or fluid in a capillary tube. In his opinion, the latter type is dangerous, as a leak in the pressure system renders the device inoperative without visible indication of trouble until it fails to operate—and perhaps the load lost. The motor-operated valve, of course, depends upon the continuity of the wiring and the 100 per cent behavior of the motor, which is usually small and operates through a reduction gear, the friction of which is a large percentage of the total power required. The author's experiences with both of the above types have been unhappy, in that both types have failed to function on many occasions, resulting (fortunately in one case only) in the loss of 5000 kw. of distribution load for about one hour. A water valve has been made up of standard materials; this by means of current flowing through a solenoid, holds the water off. The opening of the circuit to the solenoid by the thermostat allows the law of gravity to turn the water on. This device is in effect a closed circuit one and accidents (electrical or mechanical), can result only in wasted water. Some of these devices have been in operation in St. Louis for two years without a failure and almost all station transformers, under Mr. Millan's care, either have been or are being equipped with this type of valve.

No attempt has been made to protect against failure of induction regulators for distribution circuits, other than to depend on the overload relays to clear them from the line when failure actually occurs. The induction regulator is admittedly a weak piece of apparatus because of its very nature; and it would seem advisable to take steps to give them at least temperature protection. There is a tendency on the part of the operating companies to allow their distribution feeders to become overloaded and, with regulators designed for a 55-deg. rise, this abuses the regulator. The failure of an induction regulator in a manual station may not be serious when an operator who can operate a fire extinguisher is present; but here, again, in

the automatic station, we have in most cases failed to provide any protection against fire except faith. Automatic equipment possesses only the intelligence which is incorporated in its design and this falls short of human intelligence in that we have not as yet been able to give it all five of the human senses. It can only feel but does not possess the senses of smell, taste, hearing or sight. In manual stations many serious accidents have been forestalled by the operator's ability to "smell something getting hot," hear the growl of an arc or see smoke issuing from a piece of apparatus the protective devices for which have not felt the necessity of removing it from the line; that necessity not being felt until the trouble has developed into a short-circuit, which usually means fire. In general, while this class of station may be said to be satisfactory, it is obvious that there is still a very extensive field in which to progress.

Automatic D.C. Substations Feeding Heavy Edison Networks

This class has been developed mostly along the lines of single-unit stations consisting of a motor-generator set or synchronous converter located here and there throughout systems, the major portion of the system being manually operated. This means that the automatic stations are merely followers supplying power to parts of the net-work which grew out of the original manual capacity. In systems of over 30,000 or 40,000 kw., cases where automatic stations are the predominating factors are extremely rare; if, in fact, there are any at all. Where the system is so heavy, it is usually of high density and this in turn means not only a large number of stations but stations of such capacity that several large units per station are necessary. With these large stations close together, parallel operation begins to present a problem. To begin with, the demand upon the operating attendants in the manual stations of such a system is that they hold the "standard feeder-end pressure" to within one volt (0.5 v. per side). There is a reason for this other than the required candle power of customer's lamps, and it is a fact that by lowering or raising the voltage in a station one volt from standard, upwards of 1000 kw. of the load will be shifted to and from adjacent stations. The author stated that he has been unable to find on the market an automatic regulating device which could be applied to this class of service and which might be adjusted to give closer than 1.5 v., plus or minus (a zone of three volts) on the 240-v. basis. It is obvious that then the stations would not only not give sufficiently close regulation but would be continually "stealing" load from each other. It might be possible, of course, by means of costly pilot circuits to prevent the load from shifting, but we should still lack the precision in voltage regulation at the customer's lamp.

On voltage regulators it would seem that some intensive development is necessary. The voltage regulator being the keynote to this situation, too much stress cannot be placed on this point. The question of parallel operation of any number of machines in the same station is being worked upon and there seems to be no doubt that all obstacles will ultimately be overcome; not, however, without doing some things that have never been done before. It is always possible to make each machine literally an isolated station by feeding directly into the system over its own feeders, but it means that all copper is not working on light loads unless some extra money is invested in heavy bus tie breakers and, after all, it is dodging the main problem.

While the apparent "intelligence" of some of the d.c. automatics now in service, is remarkable, we are still relying too much upon pilot wires and periodical inspection to approach the intelligence of an operating attendant. We must remember that automatic equipment will do just the things we build it to do and, incidentally, keep on doing them even if dangerous to life or property. In other words, it cannot use judgment, change its mind nor respond to the dictates of fear. This means that the equipment comprising an automatic station must be rugged in every detail. For example, it would not be desirable to protect all d.c. circuit-breakers with temperature devices and they

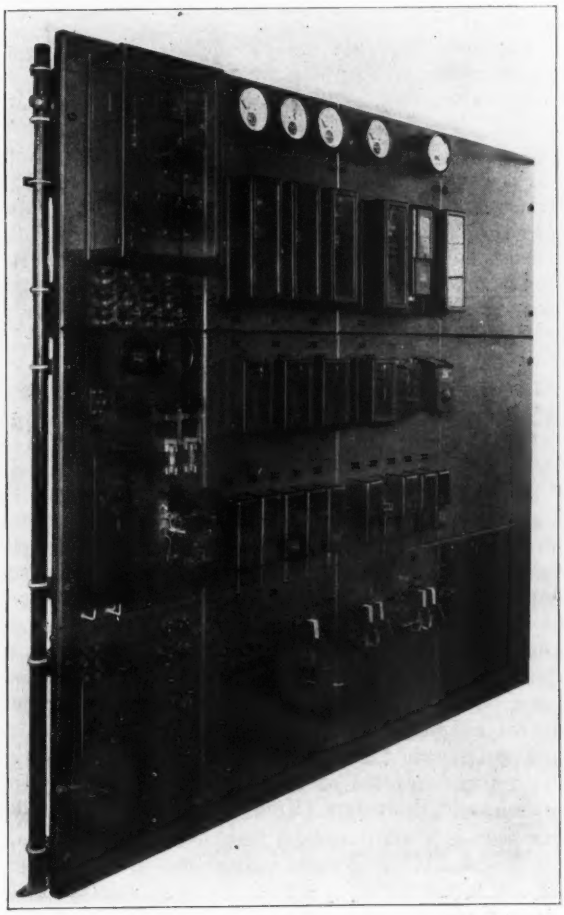


FIG. 3. AUTOMATIC SWITCHING EQUIPMENT FOR SYNCHRONOUS CONDENSER 7500 KV.A, 13,800 V., 314 AMP., 3-PHASE, 3-WIRE, 60 CYCLES

should therefore be selected so as to allow ample margin. Based on actual experience, it is felt that no d.c. circuit-breaker in this class of service should be operated at a contact brush density of more than 350 amp. per sq. in. If heavier duty is imposed it is possible for a breaker to heat up so quickly that its bridges will be annealed before this is discovered. The use of "maximum" thermometers the fluid columns of which remain at the highest point reached unless shaken down intentionally are recommended. One of these thermometers on the contact block of each breaker will divulge, to the inspector, the value of

the highest temperature reached during his absence and an oxidized contact can be caught before the critical point (annealing) is reached. This same idea may be applied to bearings, as the only protection they now have is through the medium of a gas type thermostat by which the machine is locked out when a dangerous temperature is reached on any of the bearings.

Ventilating equipment is another factor that should be fortified with ample margin and ruggedness, as in most cases the station cannot operate unless its ventilating equipment is delivering. Again the "maximum" thermometer is useful, as it can be applied to the machine and outside temperatures in conjunction with recording load-indicating devices to determine if the equipment has been properly cooled in the absence of the inspector and a brewing case of trouble arrested.

The method of tripping oil and air circuit-breakers and contactors is one that should have close attention. There is a tendency to employ, so far as possible, standard breakers which almost always are held in by a mechanical latch or toggle. This must be struck sharply by the tripping solenoid actually to open the main drive. Breakers furnished for standard manual application have been known to fail to trip on the first impulse of the tripping solenoid and as there is no attendant in an automatic station to follow up and trip it manually, this breaker remains closed. Mr. Millan feels that a holding-in type of latch should be used in these applications, as it does not depend on the continuity of an electrical circuit for its operation. In some cases this is not possible, as in the case of automatizing an existing station already equipped. At St. Louis this problem has been partly solved by the application of two relays in the tripping circuit, so connected that if the main device does not open at the first impulse, it is followed up by a succession of hammer blows which will either open the toggle or break it, in which latter case the main device, although broken, would be opened. Too much stress cannot be brought to bear on the matter of auxiliary switches on the mechanisms of all types of breakers. Originally these switches were for the sole purpose of operating indicating lamps and an occasional interlock. In an automatic station there is hardly an operating circuit that does not interlock through the auxiliary switch of some breaker or contactor and it follows that the failure of almost any of these auxiliary switches will cripple the station.

General

While progress is being made, there is still too much of a tendency to be satisfied with some questionable equipment as its exists. It is necessary that we look further into the future and in solving the problems which we encounter as we go along, bear in mind the importance of leaving sufficient margin so that that particular thing will be forever placed behind us.

Old Station Grows to Large Proportions

Bennings Station at Washington Keeps Abreast of Steam-Electric Power Developments. By W. R. McCann*

IT IS EVIDENT that a power station that has run the gauntlet of steam turbo-generator development would not be selected for a major extension of generating facilities, were not the increment investment therein sanctioned by excellent engineering and economic reasons. Bennings Power Station, one of the earlier of the steam turbine stations, and one that is still growing, emphasizes something which perhaps is overlooked in many power developments—that a power station, although old in years, may be both modern and highly efficient.

The Potomac Electric Power Co.'s initial installation at Bennings consisted of two 5000-kw. General Electric vertical turbo-alternators (Units Nos. 3 and 4), installed during 1906 in an attractive concrete block structure on the east bank of the Anacostia River in the southeastern part of Washington, D. C. The following year, two 2000-kw. vertical units, moved from another station, were installed in the positions now occupied by Units Nos. 1 and 2. The fifth unit, completed in 1909, was also of the vertical type and was rated at 9000 kv.a.

With the better efficiencies then available in 9000-kv.a. turbines, Bennings Station was forced into its first reconstruction. During 1912 and 1913, Units Nos. 1 and 2 were replaced by larger vertical units, each 9000 kv.a. in capacity, and no material change was made in the pleasing exterior of the station building, or in the general interior arrangement of turbines and boilers.

*Stone & Webster, Inc.

FIG. 1. BENNINGS POWER STATION, WASHINGTON, D. C.

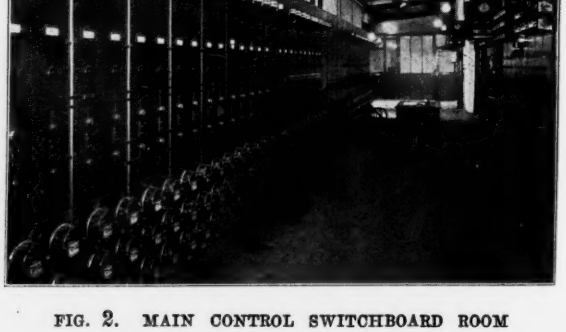
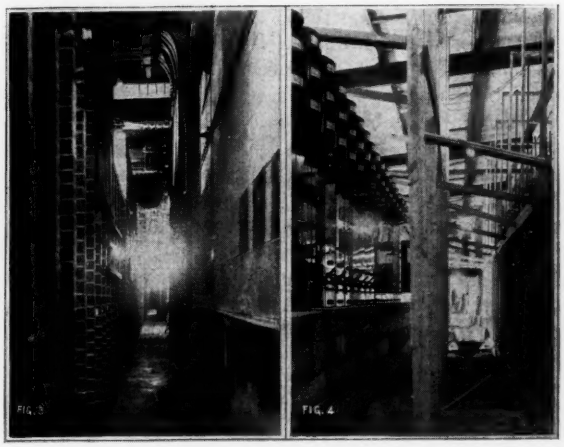


FIG. 2. MAIN CONTROL SWITCHBOARD ROOM



FIGS. 3-4. VIEWS SHOWING SOME OF THE RECONSTRUCTION WORK IN PROGRESS

Fig. 3. Passageway back of oil circuit breaker before the 1921 reconstruction; narrow aisle made repair work difficult and disconnecting the oil switch hazardous as well as inconvenient. Fig. 4. Close quarters during 1921 reconstruction. Four feet of passage, cluttered with studs and forms for new bus compartments proved to be only an inconvenience of two months duration in the operation of the old main control switchboard which is shown with relays boxed in and with slightly less than 2 ft. of clear space for the operators.

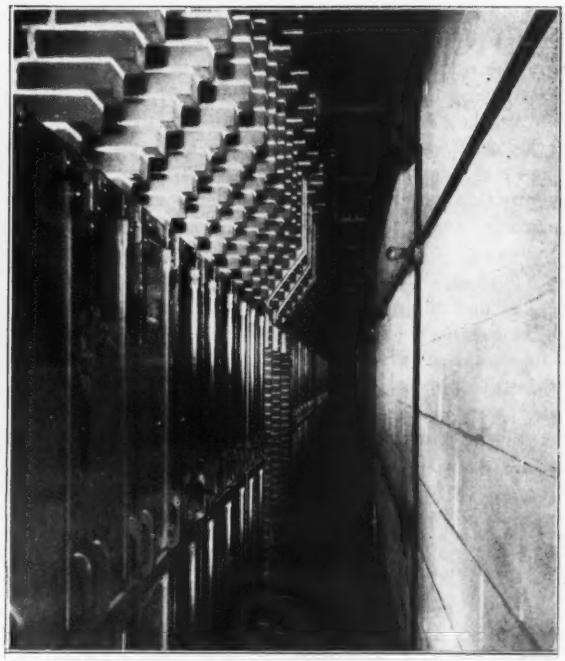


FIG. 5. REAR OF OIL CIRCUIT BREAKERS AFTER THE 1921 RECONSTRUCTION

A wider aisle made it safer to open the disconnecting switches located in the recesses at the top of the brick compartments.

The next step in the development was a building extension in 1917 for the installation of two horizontal 15,000-kv.a. turbo-alternators, which were completed in 1917 and 1918. The exterior of the turbine room, electrical bay, and boiler room indicated by their lines but little of the changes and progress made within. Unit No. 8, rated at 20,000 kv.a. was commissioned for the peak load of 1919. At the end of that year, Bennings had developed into a station of 90,000 kv.a., and was carrying over four-fifths of the Capitol's electric railway, power and light load.

During 1920, increased duty on the switch gear and on the 6600-v. bus, coincident with the growth of electrical load on the power system in Washington, developed complications at Bennings Station and made it manifest that the existing bus and switch gear were inadequate for meeting electrical requirements. After careful study, it was decided that new electrical equipment should supplant the obsolete portions of the old.

Bennings Station was now to undergo its second major electrical reconstruction. It emerged, less than a year later, with a new double bus and with feeders H-connected through reactors—all within the original narrow confines of a two-story electrical bay and basement.

A third reconstruction occurred in 1922 and 1923, when a combination of a change in generation from 25 cycles to 60 cycles and an improved economy of steam turbines, caused Units Nos. 4 and 5 (7500 kv.a. each) to be supplanted by two 60-cycle horizontal units, each of 12,500 kv.a. capacity. This replacement is of more than passing interest, in that the new horizontal turbo-generators, which were placed on the same condenser bases as the old vertical units, utilize the same auxiliary steam equipment and boilers as the old ones. The efficiency of these horizontal 60-cycle turbo-generators, moreover, is such that 12,500 kv.a. of output is now obtained for practically what 7500 kv.a. had cost in the operation of the older vertical units.

The latest development at Bennings is a major extension contemplating 75,000 kv.a. additional 60-cycle capacity ultimately, in three units to be installed during the next decade in a power station which, from a point of view of age, might be said to have long ago passed its prime. Unit No. 9, rated at 22,500 kv.a. and in service on the 1924 peak, is located in the row with, and just north of the string of eight prototypes. The turbine room in appearance has been altered little. The general exterior of the electrical bay extension, though somewhat wider than its older companion, is not dissimilar enough to mar the pleasing appearance as one approaches from the city. Taller stacks mark the more recent parallel arrangement of firing aisle in a new boiler room, which is slightly separated from the older boiler rooms with their arrangement of firing aisles at right angles to the turbine room.

Unit No. 9 and its auxiliary equipment do not portray the refinement of some of the latest power stations of large capacity and higher steam pressure. The installation, however, reflects a substantial, well balanced design, with rugged and efficient equipment that should insure continuity of operation at good economy. The new unit, without doubt, will still further improve the economy of Bennings Station.

Electrical Reconstruction Work

Electrical reconstruction work completed early in 1922 involved the converting of inadequate 6600-v. switch gear and main bus work into a modern installation. This reconstruction included the replacement of the entire former control switchboard with a new one, the razing and rebuilding of compartment barriers to obtain safer aisle passageways, the installation of complete control conduit to the new switchboard, the construction of an entirely new double bus to supplant the former single main bus, the installation of reactors in all feeders and in sections of the main bus, and miscellaneous work such as rerunning cables and reconnecting No. 8 generator from 13,200 v. to 6600 v.

As much as possible of the old equipment was utilized. The old type H-3 oil circuit breakers, in series with new

reactors, were considered adequate for present day conditions. It was not feasible to install temporary switch gear. Only one or two generators of the eight could be temporarily released. The fall peak load of 64,000 kw. had to be carried. Piecemeal construction—the taking out of service of a few feeders with one or two generators at a time—was adopted. Unusual care was essential in every construction operation. "Hot stuff" was entirely too close for ease of mind. The job as a whole, from either a construction or an engineering point of view, could have been done with far less difficulty had it been a new station.

The new main control switchboard was placed at one end of the electrical bay, in a room 36 ft. long and wider than the 14-ft. bay, by the 4-ft. width of a balcony that was built into the turbine room. Generator and exciter panels were placed on the turbine room side of the switchboard room and the feeder control board was placed facing them, with a 10-ft. operating space between. This switch-

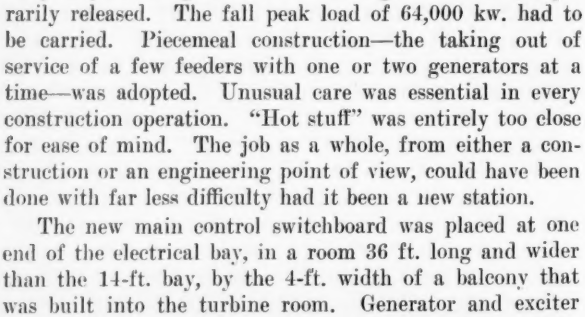


FIG. 6. 13,200-V. OIL CIRCUIT BREAKERS

board room provides reasonably well for the further development of the future.

Space occupied by some 80 or 90 ft. of former switchboard was converted into a high tension room, to house the feeder reactors and the new double bus. An unusually difficult bit of construction and operation was effected before the old switchboard could be removed. It was necessary to build 100 ft. of concrete compartments and barriers for the new double bus in front of the old main switchboard and along its entire length. The 14-ft. bay width did not admit an over-supply of working space for either construction or station operations. The board, controlling eight turbine units and about 30 feeders, was operated under these conditions for about two months. Concrete was wheeled in barrows and the forms were filled on the near side of the posts, while switchboard operation was maintained on the far side.

One of the most satisfactory reconstructions was accomplished by providing a satisfactory, though restricted, passage back of the oil circuit breakers. The former vertical high tension leads, tapping the main bus, were practically unprotected at a place where operators were called upon to pull disconnecting switches. With the removal of the old bus, it was possible to increase the width of passageway and to place doors over all lead compartments.

Turbine and generator replacements of 1922 and 1923 involved relatively few difficulties, either of design or construction, and such difficulties as occurred were encountered for the most part in the fitting of new and larger equipment into the restricted space allotted to the older and smaller vertical units. Improvement, nevertheless, was obtained in both the mechanical and the electrical installations, particularly in a betterment of the generator leads and in the providing of differential relay protection.

Bennings Power Station today represents a careful husbanding of generating facilities, reasonably modern, efficient, and economically justified—and is planned to take care of future requirements for some years still to come.

Distance Between Shaft Centers

By W. F. Schaphorst

EVERY once in a while somebody wants to know the distance between shaft centers. The length of belt and the radii of pulleys are known quantities, but the question is: "What is the distance between centers?" This question is likely to arise, for example, where an endless belt has been made and where machines are to be set at correct distances from the driven shaft, or where shafting is to be properly spaced to fit the belt.

To assist in the solution of the problem I have taken two of the best known and most used formulas and from them have developed the two rules below. Where there is considerable difference in the diameters of the pulleys, apply the first rule, which I am calling "Rule No. 1."

Rule No. 1—All measurements are in inches.

1. Square the length of the belt.
2. Multiply the square of the sum of the radii by 9.87.
3. Add (1) and (2).
4. Multiply the sum of the radii by the length of the belt and then by 6.28.
5. Multiply the square of the difference of the radii by 4.
6. Add (4) and (5).
7. Subtract (6) from (3) and extract the square root of the difference.
8. Divide by two.

This gives the difference between shaft centers in inches.

The following, which I am calling "Rule No. 2" is much simpler than Rule No. 1 but it is less accurate for pulleys that are not equal in diameter. It is accurate for pulleys that are exactly equal in diameter but as the difference in diameter increases the rule becomes more and more inaccurate.

Rule No. 2—All measurements are in inches.

1. Add the radii and multiply by 3.14.
2. Subtract this from the length of the belt.
3. Divide by two.

This gives the distance between shaft centers in inches when the pulleys are equal or nearly equal in diameter.

CORRECTION NOTE: On page 497, May 1 issue, in the article entitled "Eagle Paper Company Now Produces Own Power," it is stated that the Terry geared unit operates at 1800 r.p.m. That unit operates at 4510 r.p.m.

PIPE EXPANSION bends should be made with the minimum radius at least six diameters of the pipe.

Training Course Develops Power Plant Personnel

EFFICIENT POWER PLANTS DEMAND EFFICIENT OPERATORS. THE FALK CORPORATION DEVELOPS THEM IN AN APPRENTICESHIP COURSE. BY H. A. FROMMELT*

DISCUSSING the training of young men for power plant work, an old stationary engineer insisted that one of the essential features of this training should consist of a considerable amount of training in machine shop work. He maintained vigorously that, unless a young man had an opportunity to become something of a machinist before he entered upon his power plant work, he was likely to be limited in qualifying for opportunities later on in life. He insisted that without such training only the exceptional ones would keep themselves from being classified as mere "Starters and Stoppers."

Modern developments in power plant equipment and operation, however, have tended to destroy completely any tradition of training for power plant engineering. It is true, of course, that a young man wishing to devote his life to this kind of work realizes that he must spend some time in the boiler room and some years in the engine room before he is qualified to take his examination. The fact remains, however, that a definite course of training, whether it be solely confined to the power plant or to the power plant and machine shop, is almost unheard of. Our attention and interests have been, during the past few decades, almost wholly concerned with the purely technical and engineering features of power plant equipment and operation. The demand for greater and greater efficiency has unfortunately focused our attention upon B.t.u. and pounds of evaporation per pound of coal to the exclusion of the effect of the human element upon this problem. The result has been, for the most part a catch-as-catch-can hiring system for the boiler room in the hope that some of these casual laborers might develop into interested and competent stationary engineers and power plant operators.

Efficiency Depends on Personnel

This is, to say the least, an unfortunate attitude. It is not true that power plant work and conditions are less influenced by the human element than are other manufacturing operations and departments. Perhaps in no other section of the industrial plant can an intelligent and well-trained personnel effect greater economies than in the production of power. It is true that modern power plant machinery and equipment has been highly developed with a view to obtaining ever more and more power from every pound of coal that is burned under our boilers. But it is another matter entirely to have this fact properly appreciated by those operating our power plants. Unless they have been sufficiently trained, the proper selection of this more efficient equipment will not be made. Neither will this modern equipment be properly managed and operated. It is a far cry, after all, from the existence of efficient power plant machinery to its proper selection, management and operation. Between these two stands the human element. And it is this link in the chain of producing power which has been to a great extent neglected, if not entirely overlooked.

Until we give as much attention to the training of the personnel for our power plant as we do to the location, construction and equipping of the power plants themselves, we leave untouched one of the vital factors in power plant efficiency. This training must be thoroughly organized, supervised and truly educational in nature. We cannot expect that a young man will be thoroughly trained if we allow him merely to drift through the boiler room operations into those of the engine room, gathering his training and knowledge as best he can. There must be a planned course, not only for the work itself but for the related study as well. There must be some effort made not only to train the beginner in the right methods of performing the various operations, but also to the teaching of the technical principles underlying these operations. Some experience in machine shop work would seem to be essential, or, at least, highly desirable. The young apprentice must be guided through his course; he must be changed from one department to another according to the demands of his prearranged schedule. He must be given an opportunity to do his studying of related matter at some time during the working day. His evenings should be reserved for voluntary efforts which can be guided into the proper channels with sympathetic supervision.

Typical Plan for Training Power Plant Personnel

When The Falk Corporation undertook the establishment of formal apprenticeships in its various manufacturing departments, the power plant was not overlooked. True, the number of men employed in this work, compared to the other departments, is relatively small; yet the effect of an efficient apprenticeship for its power plant personnel was appreciated. Courses were laid out to include the actual plant work as well as the schedule of study. The following is a typical schedule of operations and their corresponding time allowances for operating or power plant apprentices:

Small lathe	450 hr.
Planer	400 "
Shaper	400 "
Milling machine	400 "
Erecting	770 "
Firing and Water Tending	2450 "
Oiling and operating	2450 "
Total	7320 "

As will be seen from the foregoing, one-third of this total training time is spent in machine shop and erecting shop work. This is possible in a plant such as that of The Falk Corporation, in which a machine shop is one of the main departments. The young apprentice is usually given an opportunity to spend his first year in the machine and erecting shops. After that he enters definitely upon his power plant experience according to the foregoing schedule. Here the operations are subdivided as well as supervised more in detail than the schedule shows. Thus 3 yr. are spent according to a planned schedule of work.

Likewise the time spent in the studying of related matter is definitely scheduled and organized. According to the Wisconsin Apprenticeship Law, all apprentices must be sent to the local vocational school one-half day per week during the first two years of their apprenticeship. In the case of The Falk Corporation apprentices, this time has been extended to cover the entire term of training.

*Apprentice Superintendent, The Falk Corporation, Milwaukee, Wis.

During this time, the students spend these 5 hr. per week in classroom study of the technical and engineering subjects with which they must be familiar to be thoroughly capable stationary and operating engineers. Boiler and power plant tests are a part of this study, which will range from shop mathematics to the more technical subjects related to power plant equipment and operation.

Probationary Period Lowers Apprentice Turnover

During the first three months of the apprenticeship, which is generally known as the probationary period, the applicant to this apprenticeship spends his time wholly at the vocational school, although he is a regular employe of the company. One half of his time is spent in the school power plant and engineering laboratory, the other half in class-room work. While some knowledge of stationary engineering work can thus be obtained, this is not the primary object. It is intended that during this time the applicant will have an opportunity to become acquainted with the nature of his chosen trade and thus be able to decide whether or not he wishes to make it his life work. On the other hand, the instructors, who are thoroughly competent and practical men, acting as representatives of the company, can determine the fitness of the apprentice for this work, in so far as this is humanly possible. In other words, this probationary period is primarily one of vocational guidance. The turnover among probationary apprentices is thus made to fall upon the school rather than upon the shop. The vexations accompanying this turnover which usually fall most heavily upon the foremen, or in this case, the chief engineer, are eliminated. Moreover, the young man is not entirely unacquainted with power plant operations and equipment when he enters the company's power plant. Those in charge of the training during his active apprenticeship are thus relieved of many of the burdens that come from entirely uninitiated help.

Location of Plants Helps Training Course

It may be objected that machine and erecting shop experience is impossible for many power plants. It may be of interest in this connection to know that the Milwaukee District Plan of Apprenticeship contains within itself the possibilities of overcoming such an obstacle. Primarily for the purpose of training machinists and molders, larger plants were made the centers about which smaller machine shops and foundries were grouped for the purpose of carrying out a co-operative schedule of training. Smaller plants, employing relatively few men, would be unable to operate a complete and adequate apprenticeship course because of lack of diversity of operations. Hence schedules are drawn up calling for a certain portion of time to be spent in a smaller shop and the remainer in the larger or central plant of that group. In this manner, all plants, regardless of their size, can participate in these training activities. No matter how specialized their product or sub-divided their operations, they can present some small opportunity towards completing a full and adequate apprenticeship.

This same arrangement, with few and minor changes, could be made to apply to the training of power plant personnel. Thus, for example, a power plant in connection with a textile establishment where no machine experience was available, could ally itself with some manufacturing organization having a machine shop in the community with the object of providing this highly desirable machine-and erecting-shop experience. This species of co-operation, which now exists in the Milwaukee district among certain groups of metal trades plants, can easily be applied to that of power plant training. Its principal requirement is a spirit of co-operation and of frankness among those carrying on such training activities. It requires, moreover, the vision to realize that this problem of training the human element for our industrial work is a community problem and one to which those who are affected should justly contribute.

Power plant operation requires a highly skilled personnel. It should be obvious that to produce this personnel a definite course of training and study must be applied. The old, haphazard system must be replaced and modernized to conform to the developments that have taken place in the engineering and technical phases of modern power plant work. A formal apprenticeship or period of training is the only adequate method. If this is done, then and only then are we giving that attention to the human element that it deserves; and this is probably more true of power plant personnel, because of the requirements and the nature of the trade and profession, than of any other. A thoroughly organized, planned and supervised apprenticeship will provide the trained personnel that our modern power plants deserve.

The First Link in the Evolution of Chain Drive

SOMEWHAT over 50 yr. ago an aspiring young inventor in the town of Belle Plaine, which is in Iowa, let his thoughts stray from the gospel while the pastor droned his parables.

There is nothing unusual about such a happening even in these modern times, but the point of this particular incident is that the young man in question—William Dana Ewart by name—was both inventor and dealer in agricultural implements for those who raised fat hogs and high corn in the region thereabouts—and the reason he could not pay the required attention to the sayings of Saint Paul was that he was trying to solve a puzzle, was trying to find the answer to a problem which would mean better farming.

His "crossword puzzle" was to find the "verticals" and "horizontals" which would result in a square chain link which could be detached by the farmer working in the field when the chain drive of his new fangled "self-binder" broke down. Once made detachable, farmers would save hundreds of wasted hours which were then being spent in galloping to the nearest blacksmith shop to repair the old-fashioned square link being used on the binder drives of those days. He knew the shape of the link was all right—if it could only be detached.

As the young inventor's ideas strayed afar, his fingers found a handy sliver of wood and its bed-fellow, the trusty old Barlow jack-knife our fathers knew so well. The result was a crude model of a detachable link.

How many casual readers of this churchly incident would surmise that this piece of whittled wood resulted in an amazing donation to the speeding up of industry?

Mark what an idea can do:

United States Patents granted to William Dana Ewart in 1874 for "an improvement in drive chain," played a major part in the revolutionizing of agricultural implement

machines. Our basic industry of agriculture was made more productive and profitable through elimination of harvesting troubles.

With only minor variations from this original design, billions of links of modern chain have been produced.

Chain being in turn a basic factor in the conveying art, it is used wherever materials are moved. Detachability has proved just as much an economic factor in industrial fields where chain is used as it proved in the fields of waving grain. This is particularly true of direct drives for the economical transmission of power in manufacturing plants of many types.

While the art of manufacturing malleable iron and steel has advanced far beyond the dreams of 50 yr. ago, it is a historical fact that the original crude model referred to has been responsible for many other chains of various sizes and types in which the detachable feature is not needed. Such chains have played a big part in the economic life of our own and other countries.

Chain, as employed in great public utility plants and our factories, brings cities closer together; makes the automobile dollar go far; helps to keep down the cost of stockings for flappers and sox for farmers; helps the stockyards to deliver the housewife a cheap cut of ham or roast. Every ton of anthracite coal handled in this or any other country under modern storage methods owes its handling to a system which in turn owed its creation to the crude wooden model carved out in the dark of the pew. And coal costs less as a consequence. The list could be extended ad infinitum.

After all, chain, to which most of us give scant thought, can truly be defined as an indispensable of today. The world could not speed along without it.

Give credit in passing, then, to the inventive contribution to welfare resulting from a mind which wandered from the gospel more than half a century ago. A crudely whittled model was destined for the niche of fame, yet not one man in thousands has heard the story before.

That's why we are glad to print it here. Such stories do not make us feel so harried over the solution of the six-word question:

What do subscribers like to read?

Right Conditions Aid Hydro-Electric Operation

EFFICIENT APPARATUS; PROPER PROVISION FOR SPEED CONTROL, AUXILIARY POWER AND DISTRIBUTION OF LOAD; ADEQUATE EQUIPMENT FOR EMERGENCIES AND PROTECTION ARE NEEDED. BY CHARLES B. HAWLEY*

IN HYDRO-ELECTRIC development, the governing criterion as to expenditure to secure additional power should be the estimated value of the power to be gained as against the cost of capital investment required to secure it, taking into account all fixed charges. Improvement in efficiency is warranted up to the point where cost of securing an additional unit of power adds to the average cost of power from the entire development.

SIZE OF CONDUITS

On the above principle, it has been determined that the gross area of intake racks should be such that the velocity through them will be not over 2½ ft. a sec. when the turbines are running at full gate and head. For penstocks, general experience has shown that velocities in excess of 10 ft. a sec. can hardly be justified except for very large penstocks and pressure tunnels.

GENERATOR EQUIPMENT

While purchase on a heat rating basis is, perhaps, fair, yet a slight modification to include justifiable compensation for increased efficiency will usually benefit the customer by increasing power and giving reserve electrical capacity. This latter benefit is somewhat intangible but is desirable, in view of the tendency to increase head after the plant is installed by means of gate controlled spillways and increased draft head.

As to the wheel runner, most engineers prefer a high speed characteristic as it gives high peak efficiency and, for low or medium heads, results in economy of generator construction. The latter follows, however, only up to a speed of 300 r.p.m. for generator cost in large machines begins to increase when speed exceeds 300 to 350 r.p.m. It then becomes necessary to balance the increased generator cost against the advantage of runner design for high speed, when using the reaction turbine, which is now built for heads up to 1000 ft., the field of the impulse turbine being limited to extremely high heads or to small units under medium heads.

Peak efficiency, even over a comparatively small range of gate openings, is justified by the fact that most large hydraulic plants are tied in with larger power systems so that the capacity of one unit is small as compared with that of the whole system. It is, therefore, usually possible to limit the operating range of the wheel to 0.65 to 0.85 gate opening which will be on that part of the efficiency curve where high values are found. In small plants which have no pondage, hence must use the stream flow as it comes, it may be better to use a lower speed characteristic so as to get satisfactory efficiency over a wider range of gate opening and use the stream flow under more effective operating conditions. The same result may be obtained by using two units of different sizes but this tends to add to the expense of power house equipment and requires carrying spare parts for more than one size of unit.

EFFECTIVE HEAD

Frequently, allowance has not been made for losses of head in intake racks, penstocks and from drawing down the pond at certain periods in order to carry excess load. In drawing from a storage reservoir, allowance should also be made for draw down. Assuming the greatest lowering of level to be 30 per cent, the effective head may be considered as 85 per cent of the maximum, if it is desired not to impair seriously the power capacity of the turbines at lowest level. Variation of 15 per cent either way from the rated head will not cause appreciable loss in efficiency, if the speed is held constant over the entire range of head.

When a reservoir is drawn down 30 per cent, the turbine will carry less than 60 per cent of its power at full head and this affects the proper economical rating of the generator which should always be large enough to absorb the entire output possible from the turbine under any head available. Likewise, engineers have sometimes been too optimistic as to effective draft head so that tail water has

*From a paper presented at the Third Annual Hydro-Electric Conference at the Engineers' Club of Philadelphia.

been left 2 to 3 ft. higher than was estimated. Head above the center line of the turbine is more efficient than below that line but excavation so as to lower tail water to levels estimated can nearly always be justified. In any case, each development should be analyzed for operating conditions before specifying effective head in ordering hydraulic equipment.

Controlling Speed

If a plant is the only or the largest source of power in an interconnected system, care is needed in regard to the governing and the flywheel effect of the units. A unit which shows speed increase of 35 to 40 per cent when full water rheostat load is thrown off or 12 to 15 per cent when half load is thrown off, may operate satisfactorily in actual service with other units, owing to the steadying effect of the system. Additional flywheel effect in the generator or an extra flywheel will help some but that is of slight effect as compared to the pull of synchronism which ties all the rotating parts in a system together. It has been stated that it takes 20,000 kw. to increase the frequency of a large power system one cycle per second.

Loads on a system generally creep up and down so that even a sluggish governor will hold the frequency normal. Scroll cases, penstocks and water passages may be designed for safety against a closing time of the governor of 2 sec., yet economy has sometimes influenced engineers to provide for a closing time as slow as 1 min., though 3 to 4 sec. may be considered as fairly slow. If long penstocks are used, the grade may not allow the tube to fill as fast as the governor might open on a sudden increase in load and a slow opening governor is necessary to avoid formation of vacuum or admission of air.

Closing should be made as short as practicable to prevent runaway when a circuit breaker trips or load is thrown off. Three to 4 sec. will usually do this and the casings and penstocks can be protected by relief valves or bursting plates to take care of possible water hammer. To insure against accident and guard against weakness from rust, it is well to provide a strength against a closing time of 2 sec. for the added cost is but a small item in proportion to the whole cost of the installation.

Excitation and Auxiliaries

Power is needed for pumping oil for the governor system, for excitation, for switch control, lighting, crane service and operation of gates and spillway. This power may be taken from house turbines, from auxiliary generators mounted on the shafts of the main units or at low-tension, either from the station bus or from an auxiliary bus fed from the main units by step-down transformers.

House turbines form the most flexible arrangement but are also the most costly. In low-head plants where the water goes directly from the forebay to the turbine scroll cases, the use of house turbines may mean a longer intake and power house. In the case of high-head plants, with each unit served by its own penstock, the service unit may take its supply from the penstock above the valve to the main unit, if such a valve is used, so that the service unit may be run without opening the main valve. Capacity for such a unit is only about 2 per cent of that of the main unit so that this makes a satisfactory arrangement though somewhat more expensive than taking the power from the main turbine shaft.

For driving service units, small impulse wheels may be used but should be carefully screened against leaves and small twigs which would stop up the nozzles.

For excitation, it is usual to use a small d.c. generator on the shaft of each unit which allows a Tirrill regulator to operate on the field of the exciter rather than on that of the main unit, thus handling smaller currents. A more flexible way is to use the exciters in parallel so that any unit may draw from any exciter but, in this case, the main field current must be controlled instead of the exciter field.

Another method of getting auxiliary power is to install an a.c. generator of say 2300 v. on the main turbine shaft and feed the station busses from this. Excitation is taken from a motor-generator set and service pumps driven by motors. The system may be so arranged that any auxiliary generator can supply the whole system or any part of it but the auxiliary units cannot be run in parallel, when the main generators are in parallel. If d.c. auxiliary generators are used, they can be operated in parallel and furnish current to a common station bus, the exciting current for main units being taken from this bus, as well as current for all station power. Some designers consider this undesirable as it means that all motors will be d.c. and they prefer a.c. motors to eliminate the care of commutators.

Bearings and Lubrication

Filtering and circulating systems are becoming less common for thrust and guide bearings as it is found that water coils, placed in an oil bath surrounding the thrust bearing, will allow of running without change of oil for indefinite periods. It is also found that proper babbitted bearings with oil lubrication will replace lignum-vitae bearings for a vertical unit in even the most trying conditions. Circulation is maintained through the guide bearings by a pump, the oil being cooled in the sump for high-speed installations but needing no cooling for low speeds. The oil circuit may include also the thrust bearing, in which case the cooling coils in that bearing will be sufficient.

Ventilation of Generators

In forced ventilation, air is supplied to or removed from generators through ducts arranged for the purpose, either with or without fans. Seldom does the air need to be filtered. Air is taken in from both ends of the machine parallel to the shaft and discharged through the circumference, using circulation of the air within the power house or taking the air from outside and delivering it into the house for heating in winter or in the reverse direction for cooling in summer. Whether a common duct be used for all machines or a separate duct for each one will depend on the arrangement of the plant, the object to get the best circulation at the least initial cost. When air is to be taken from outside and discharged into the room, it may be necessary to block off the top of the machine to prevent reversal of air currents. In that case, for high-speed machines, ducts may be needed through the stator so that air may pass from below the generator to the upper end of the armature to give adequate cooling.

Operating Suggestions

Best distribution of load will generally be had in interconnected stations, when all governors are set for the same gate opening, but, if one station operates on unregulated stream flow, its gate opening should be selected to pass the actual flow at that time and let other stations take care of the fluctuation of load. Also, where different sized units are used, it may be advisable to regulate the gate openings

to get the best combination of economy from the units operating.

Two frequent phenomena in operation are pitting in runners and surges in draft tubes. Pitting usually starts on the under sides of the runner blades at a point where the water leaves the runner and enters the draft tube. As a rule it is believed that this will not occur, if runners are properly designed and put into suitable settings, then operated under rated head and at points reasonably close to gate openings of best efficiency. After long periods of operation without signs of deterioration, pitting has suddenly developed after some change in operating conditions such as lowering of tail water or use of smaller gate openings. Pitting may, however, develop in even the most efficient runners but the efficiency will not be impaired until the defect has progressed so that sections of the blade are broken out.

Surges in draft tubes probably result from use of too high draft heads in large units and are more noticeable at partial gate openings than at full or nearly full opening. They can be reduced, sometimes corrected, by admission of a small amount of air to the draft tube just below the runner, which does not materially affect the efficiency of the tube, though a shorter tube would probably be more efficient. Surges may not occur at all gate openings and governors have been fitted with piston type valves which admit air to the tube at those gate openings where surges occur yet cut it off when not required. In one plant with concrete scroll case, where air could not be admitted to the tube below the runner, the surges at 0.6 gate opening were so great as to cause vibration of the entire unit and make running at that opening impossible.

Emergency Provisions

At least one gate to be closed in case of emergency, is desirable between the forebay and the turbine. Some designers prefer this to be at the entrance to the scroll case, others to have it at the up-stream end so as to protect in case of damage to the penstock. The location will depend on the arrangement of the plant. For up-stream use, the vertical sliding Stoney type or the Taintor trunnion type are adapted, while the needle valve is best for the down-stream end of the penstock or the entrance to the scroll case. If valves are installed at the upper end of the penstock, a straightway or a butterfly valve may be used at the scroll case. The cylinder gate is well adapted for use in circular tower intakes but has not come into general service.

Emergency gates may well be arranged so that they will be closed automatically from the same differential relays that protect the generator windings by opening the circuit breaker and field switch, or they may be under control of the mechanism which applies brakes to bring the generator to a stop, after the penstock gate has been closed.

This provision for quick stop after water is shut off is essential for a runner must have scant clearance to be efficient and a certain amount of water is required for seals to prevent heating. Brakes operate a little better with air pressure than with oil pressure. They are frequently used as jacks to support the weight of the runner during inspection or repair of the thrust bearing and, for this purpose, oil must be supplied under high pressure.

Recently, sprinkler systems have been installed inside generators, to prevent spread of fires as a result of short, circuits in the windings. Fan action of the rotor may cause the flames from a short to pass up through the ventilating ducts, doing great damage to the coils and laminations, though the breakdown was in only one coil. Differential relays will cut off power, open the field and stop the unit but, if considerable heat has been generated, the fire may keep on burning and it is to limit this that the sprinklers are being tried out. A heavy short usually fuses laminations as well as burning coils so that the core has to be restacked. Loss of capacity while restacking and repairing is often the most expensive part of the shutdown and, if the sprinklers will limit the area affected in the stator, it is thought that the damage from putting water on the windings will be less serious than that from a complete burnout.

These sprinklers have circular pipes resting on the stator frame above and below the coils and perforated so as to throw jets of water where they will be most effective. Water is not permitted to stand in the pipes and drains are provided so that leakage through control valves will be carried away, these drains being closed simultaneously with the opening of the control valves and all controlled by a push button on the switchboard. In one system, the pipes are divided into sections, each with its own control button, and are kept filled with compressed air. In case of a fire, a fusible plug melts and the escape of air is indicated by an alarm on the switchboard.

Power for Emergencies

During an emergency shutdown, power may be needed to raise spillway gates at flood, for lighting the power house and dam, to raise the intake gates and start governor oil pumps so that a main unit may be started. While, in most cases, transmission lines can feed back such power, contingency may arise such that a line is out of commission at the same time as the plant, hence it is deemed desirable to have some local source of power which can be used. A small steam plant may be provided or an internal combustion engine as auxiliary to the usual motor drive for operating gates and for operating an independent generator for furnishing light. This can be used in conjunction with the storage battery of the plant and will give all needed emergency power. Whatever is used should have a regular part in the plant operation, so that it will be kept in condition and be ready for use when the emergency arises.

In order to reduce governor effort for operation, wicket gates are usually designed to be balanced against water presssure when partly open. Pressure must, therefore, be kept in the regulating cylinders in order to hold the gates closed when water is in the scroll case. To avoid running oil pumps during a long shutdown, a locking device may well be used to hold the gates closed with water in the scroll case.

Spare parts needed will depend on the reserve capacity of the system and how much loss will follow waiting to get spare parts from the factory. Many think it best to have an extra runner, guide vane links, one or two guide vanes, and a spare turbine bearing shell. These may be in stock a long time without being used but they may prevent a long shutdown at a critical time. For the electrical end, it is thought sufficient to carry coils and laminations sufficient to replace only a small section of the stator, say 20 per cent of coils and 10 per cent of laminations. Collector rings, brushes, brush holders and springs, shoes for thrust bearings and guide bearing shells will almost certainly pay as insurance against shutdown.

Power Plant Development in the Orient

By W. C. Heckerath*

DURING THE summer of 1924 the writer had occasion to visit Japan and had the opportunity of seeing a large number of interesting power plants as well as meeting many Japanese engineers. A considerable number of these engineers have visited the United States as well as European countries, on tours of inspection and have familiarized themselves wth the most modern practice in power plant engineering. The character of the plants visited spoke eloquently of the progressive spirit of Japan.

Japan is not favored by an abundant supply of high grade coal as we are in this country, much of their fuel being imported from China. A small percentage of the coal mined in Japan contains as high as 13,000 B.t.u per lb., but most of it runs from 8000 to 10,000 B.t.u.

One plant visited was that of the Iwaki Coal Co. at Taira, about 125 mi. from Tokyo, where they were burning under vertical water tube boilers fitted with underfeed stokers, coal which was hardly fit to ship to their customers. This coal contained about 40 per cent ash and had a calorific value of from 5000 to 6000 B.t.u. per lb. It goes without saying that they do not attempt high overloads when burning this coal, but are able to develop approximately 125 per cent rating without encountering difficulties due to slag and clinkers. A liberal grate area must be provided.

At another plant, however, that of the Ujigawa River Electric Company near Osaka, a mixture of about 10 different grades of coal was being used, high and low grade coal being mixed before it was elevated to the bunkers, resulting in a fuel having an average of approximately 10,000 B.t.u. which permits operating the boilers at from 175 per cent to 200 per cent rating. This plant has 13 vertical water tube boilers which are about 725 hp. rated capacity. The mixing of the coal was accomplished in a novel manner, one which we could hardly afford to adopt in this country.

Coal as it arrives at this plant is stocked in as many piles as there are kinds or grades and from these piles an equal number of coolies carry the coal in baskets suspended from each end of a wooden bar resting on their shoulders, to a grid outside of the boiler room. The coal is dumped on the grid through which it feeds the boot of the elevator which carries it up to the bunker. The coolies form a procession so that each pair of coal baskets dumped are from different stock piles, in this manner accomplishing quite thorough mixing.

In most cases the boilers are fitted with mechanical soot blowers, superheaters, and economizers, and are designed for working pressures as high as 275 lb. gage. Steam turbines are used for driving units and operate condensing.

Another plant in Japan will have when completed, eight boilers of approximately 1080 hp., and eight of 1350 hp. rated capacity each and a kilowatt capacity of 100,000 consisting of four turbo-generators of 25,000 kw. each.

These steam plants supplement hydroelectric power stations of which Japan has a considerable number.

The cement industry has made rapid strides in Japan also. In these plants waste heat boilers are employed to utilize the hot gases as they leave the cement kilns.

*Sales Engineer, Erie City Iron Works.

Fuel Conservation Urged by Chamber of Commerce

IN AN EXHAUSTIVE report prepared by a committee for submission to the third bi-ennial meeting of the International Chamber of Commerce at Brussels, June 21 to 27, it is stated that although the United States has within its borders the largest supply of fuel in the world, including oil, natural gas and coal, nothing will be left within a few decades except the coal.

The committee which drafted the report was composed of Arthur D. Little, chairman, Boston; W. T. Coe, manager of the Consolidation Coal Company, London; C. E. Lesher, editor, Coal Age, New York; Van H. Manning, director, Research Department, American Petroleum Institute, New York; George Otis Smith, director, United States Geological Survey, Washington, and Thomas H. Watkins, president, Pennsylvania Coal and Coke Corporation, New York.

Radical changes in the use of fuel, necessitated by the approaching exhaustion of the domestic petroleum supplies are foreseen by the committee. The directions in which developments may come, as outlined tentatively by the committee, are in part as follows:

"Use of coal at the mines, there to be subjected to complete gasification or to carbonization, with complete by-product recovery. The gas which results to be transmitted under high pressure to the point of use where this point is not too distant. The coke to be used for the generation of electricity, to be transmitted at high tension to the point of use. Shipments from the mine plant to be mainly in the form of coke or coke briquettes.

"Electrification of railroads, using where possible hydroelectric power.

"Linking together of great central stations in a general electrical network, with high tension transmission.

"Domestic heating from central plants or by gas or coke.

"Large use of gas for industrial heating from gas generated at the coal mines. Where this is not possible, use of coke.

"The power in industrial plants to be electrical, from central-power stations linked to the general electrical network.

"Much larger development of water power.

"Abandonment of the use of petroleum products for domestic heating, for industrial uses, and for fuel on railroads.

"Increased use of Diesel engines on vessels, replacing oil-burning steam engines.

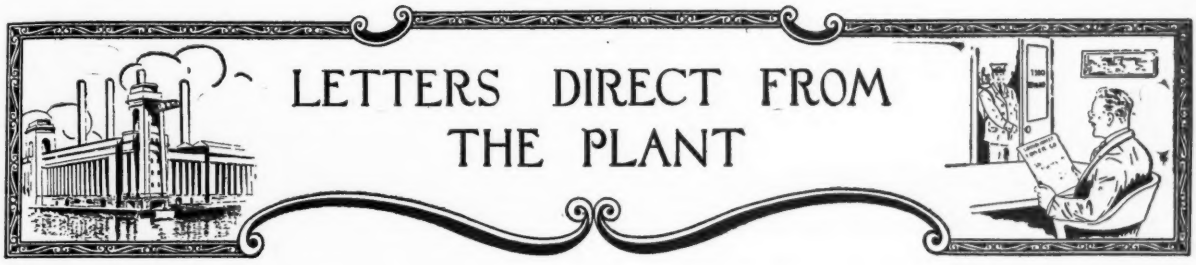
"Development of the shale-oil industry.

"Further improvement in prime movers, and especially in the automobile engine.

"Large steam plants to have coal processing plants connected with them, coke being burned as fuel, gas distributed as fuel for domestic and industrial uses, and with full by-product recovery. Exhaust steam to be used for domestic heating as far as possible.

"Abandonment as far as possible of small gas plants. Foolish antiquated standards for heating requirements abandoned. Full use of gas from the mines, from blast furnaces and by-product coke-oven plants.

"Improved methods of refining petroleum, with the special object of more complete utilization of the fractions now comprised in fuel oil.



Heat Loss in Flue Gases

I HAVE read with interest the remarks of Mr. Thornton, in the March 15 issue, on the subject of heat loss in flue gas. Several of his statements, however, will bear qualification. There is no commercial fuel of which the percentages of dry products of combustion of CO_2 plus O_2 plus CO will add up to 20.9 per cent. The stated percentages will be still lower, obviously, when figured as parts of the total products of combustion. There have been a few isolated instances, when burning wood refuse fuel, in which the summation has totaled as high as 25 per cent but these instances are exceptional and are caused

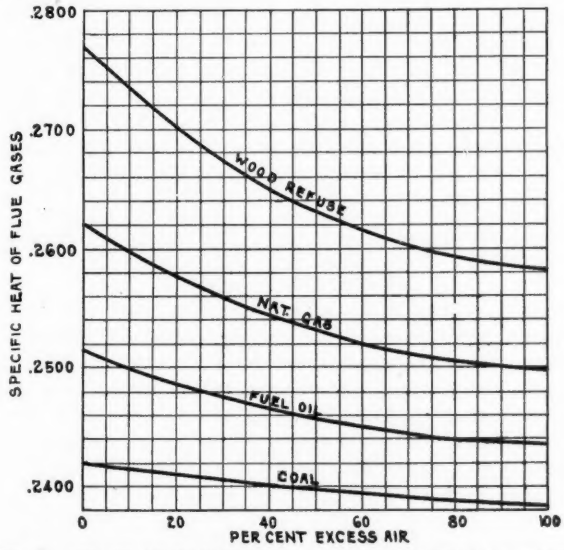


FIG. 1. CHART OF VARIATIONS OF SPECIFIC HEAT OF FLUE GASES AT 500 DEG. F. WITH DIFFERENT PERCENTAGES OF EXCESS AIR

by local distillation in the furnace. The appended chart of curves shows the varying quantities of the dry products of combustion with different percentages of excess air. The figures cover representative bituminous coal, Ohio natural gas, California fuel oil and Washington wood refuse fuel.

It is of interest to note that the oxygen content of the dry flue gases varies but little for the different fuels and that, once the oxygen content of the flue gases is known, the excess air can be closely estimated without knowing the ultimate analysis of the fuel.

The specific heat at constant pressure of the flue gases varies considerably, on account of the water vapor content, which is the product of the combustion of the hydrogen in the fuel. Figure 1 shows how the specific heat of the flue gases varies with different fuels. This variation in specific heat of the products of combustion influences the relative performances of the boiler, superheater and economizer and its effect can be observed in a plant where two different types of fuel are burned. Thus, for equal heat transfer in the superheater and economizer, the temperature of the flue gases leaving the economizer will be higher with natural gas than with fuel oil. A still greater difference

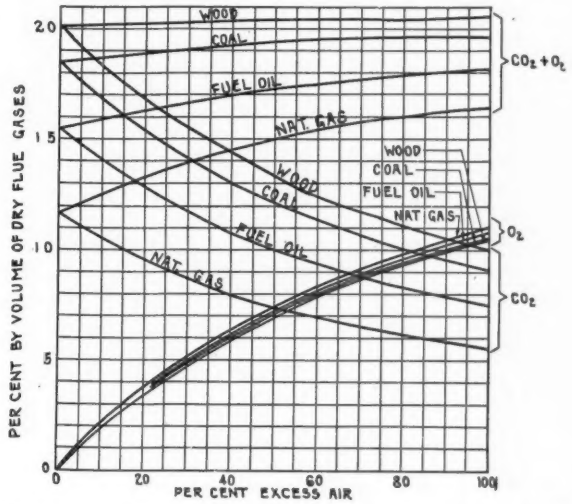


FIG. 2. CHART SHOWING VARIATIONS IN CONSTITUENTS OF DRY FLUE GAS WITH VARIOUS FUELS

will be noted when comparing wood refuse fuel and fuel oil. Wood refuse fuel at times contains as much as 60 per cent moisture.

San Francisco, Calif. M. S. GEREND.

Handling Workmen Under Varying Conditions

AS I HAVE had considerable experience in the management of repair men in a busy plant, I wish to call attention to the fact that the opinion of James H. Cox in the April 15 issue is based on the observation of the methods adopted by a friend during a short period. He seems to think that the same conditions are found during the continuous operation of the plant and this may not be true. He mentions the fact that one job was begun, and long before it was finished, it was left, and another one taken up. I have had to do the same thing many times over on account of conditions which I could not control.

As an illustration, I would begin one job that was not wanted at short notice and soon afterward another one came in that must be attended to without loss of time. To take the time to finish the job that was not wanted that day, but could be done at leisure and keep the other waiting that was needed at once, would be the worst kind of a mistake, as it would show gross mismanagement. Because

it was necessary to return tools to the tool room and call for them again, taking a few minutes of time, it would not be right to keep needed equipment idle for several hours.

New Haven, Conn. W. H. WAKEMAN.

Simple Chart Shows Proper Piston Ring Dimensions

ENGINEERS in charge of operation and maintenance of reciprocating engines have, at one time or another, usually experienced trouble with piston rings. If they have had reason to suspect that the design of the ring was at fault and have looked into textbooks and pocket manuals for information, they have realized how meager is the published data on this subject. Many piston rings have not been designed at all but merely made to some old-established proportional rule. For instance, the concentric snap ring, with which this article is concerned, if made with a radial thickness of about 1/30 of the cylinder diameter and a free gap of about four times the thickness would often prove perfectly satisfactory in a Corliss engine for example. It is obvious, however, that a ring proportioned to a rough rule of thumb will not do for all services.

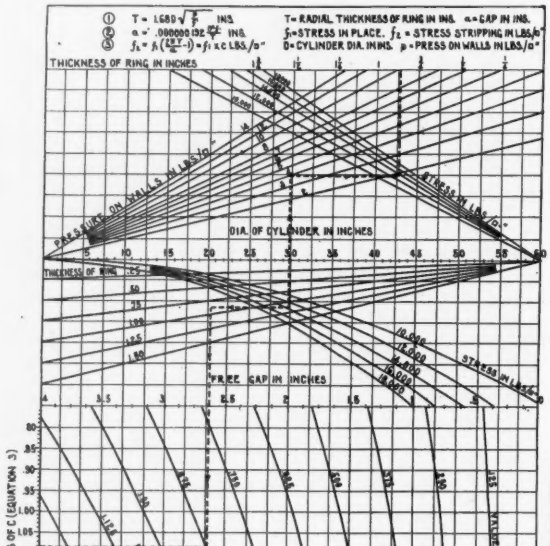


CHART FOR DESIGNING PISTON RINGS. ASSUMED VALUE OF $E = 12 \times 10^6$

As an illustration, consider the various rings in a two-stroke cycle Diesel engine. In the scavenging air pump, the m.e.p. is only a few pounds and the necessary wall pressure exerted by the ring should be about 2 lb. per sq. in. In the case of the high pressure stage of the injection air compressor a pressure of 6 or 7 lb. per sq. in. is required, while for the main working cylinder, 4 or 5 lb. per sq. in. will prove satisfactory. It will be seen that the piston-ring wall pressure is an important factor and to obtain the proper pressure, with a satisfactory working stress, the ring must be designed.

To give a rapid and sufficiently accurate design of ring for diameters of cylinder usually met in practice, the accompanying chart has been worked out. The formulas used were developed by the writer from the standard formulas of Reinhardt (Zeitschrift des Vereines Deutscher Ingenieure, 1901) and put into a more convenient shape. A full discussion of these will be found in Machinery (London) for November 27, 1924; it is only necessary to say here that the British Engineering Standards Association minimum value for the nominal modulus of elasticity for cast iron used on piston rings has been adopted as standard (12,000,000 lb. per sq. in.).

Use of the chart is best shown by an example. With a given cylinder diameter, and having decided on the necessary wall pressure, here taken as 4 lb. per sq. in., a suitable working stress should be chosen. This stress should not exceed 18,000 lb. per sq. in. and should preferably be about 14,000 lb. per sq. in. The upper section of the chart then gives the ring thickness, as shown by following the dotted line. Using the same ring stress and the determined ring thickness, the middle section of the chart gives the required free gap, or distance between the unsprung butt ends of the ring. With all the provisional dimensions of the ring determined, the bottom section of the chart gives the coefficient C, to be used in finding the stress involved in stripping the ring over its piston. If this turns out to be excessive, the ring must be re-designed. The breadth of the ring, usually from one to 1½ times the thickness, does not affect the calculations in any way. Finally, it should be observed that most piston ring trouble is due to faulty alinement or lubrication of the engine, but properly designed rings will give a noticeably smoother running engine, with better mechanical efficiency than is the case with rings made according to a rule of thumb.

New York, N. Y. BRIAN M. THORNTON.

Emergency Gaskets of Building Paper and Sheet Rubber

I HAVE read many letters describing how some fellow was securing good results and saving money by using tarred building paper as gaskets in flange couplings on steam lines. If the flange faces are in perfect condition, there is no doubt that such paper will hold the joint steam tight temporarily but, even on steam lines carrying comparatively low pressure, the paper will soon be reduced to a dried or burned-out dust and leaks will result because of the movement of the line caused by expansion and contraction.

Recently, however, an engineer described to me his method of using building paper packing, which seems to work well. He explained that he had on hand some old and very cheap sheet rubber packing $\frac{1}{32}$ in. thick. This material was all right on cold water pipe work but worthless for steam service. One day he required some packing in a hurry to use on some flange joints where the steam pressure was 130 lb. Investigation disclosed the annoying fact that the only sheet packing on hand was the old worthless stuff. Like myself, he had read about tarred paper substitutes, so he decided to experiment. Cutting two gaskets from the $\frac{1}{32}$ old sheet, and one from tarred building paper, he inserted this three-ply gasket in the flange, with the paper in the center and a coating of graphite applied to the flange faces. This made a tight job and several joints treated in this way were still steam tight when he left the plant some sixteen months later.

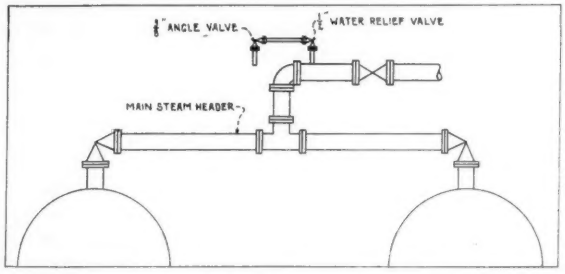
I believe that much otherwise worthless packing could be used up in this way; instead of using tarred paper, however, use thin asbestos paper between the rubber.

Toronto, Can. JAMES LONDON.

Auxiliary Safety Valve Acts as Signal

To NOTIFY the fireman that boiler pressure is near the point at which the safety valves pop, we find the simple appliance illustrated in the sketch of considerable advantage. To operate properly, the ½-in. relief valve should be set only a few pounds below the blowoff point of the boiler safety valves. To adjust this valve, raise steam slowly on the boilers, with the ⅜-in. angle valve wide open, until the ½-in. relief valve opens and discharges through the bottom of the angle valve. Then throttle the angle valve until the relief valve chatters. This chattering is a warning signal, loud enough to be heard distinctly but not loud enough to be disagreeable, and the fireman then knows that the boiler requires attention or the main safety valve will soon operate.

Complaints from the neighbors on account of the nerve-racking noise, sweating of cold water pipes caused by condensed steam, plugging of steam gages and traps due to sediment carried by rapid circulation, as well as shock to the fireman and unnecessary loss of steam, all caused by



SKETCH SHOWING METHOD OF CONNECTING RELIEF AND ANGLE VALVES

frequent popping of safety valves, are now things of the past with us. The satisfaction of knowing that this disagreeable occurrence can be prevented, with an equal degree of safety as before is, I believe, in many boiler rooms well worth the time and expense of such equipment.

Kansas City, Mo. H. S. FAIRCHILD.

Steam Meters Save $6000 a Year

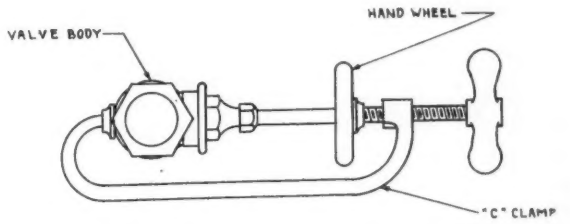
I HAVE before me a report regarding the installation of 16 steam meters in a large plant in which it is claimed that the meters pay for themselves annually by showing how exhaust steam can be used and by effecting other economies. This company has a daily production of 135 T. of high-grade paper. Their power cost runs into several thousands of dollars per day, being from 40 to 47 per cent of the total production cost. Therefore, as the report states, "the generation and use of steam are entitled to almost as much study as all of the other plant operations put together."

This power plant consumes an average of 100 T. of coal screenings per day and 6 car loads of "hog feed" or wood chips from the sawmill. Eleven flow meters were installed in 1919 and now they have 16 in operation. There are 11 on the boilers, one on the distribution line to the digester, one on the line to the big engine, one on the line to the bleaching plant, and one each on the 10-in. and 8-in. lines supplying several machines. One of the interesting statements in the report is this: "A study made possible by our meters determined that exhaust steam from our 1000-kv.a. engine could be used on our bleaching machines in the place of live steam. On this item alone we saved in one year more than $6000, which repaid the entire cost of our meters."

Newark, N. J. W. F. SCHAPHORST.

Disabled Valve Held Shut by Machinists' Clamp

ONE DAY after I had opened the ⅜-in. globe valve to blow out the gage glass on one of the boilers, I found that I could not close the valve again, as the threads on the



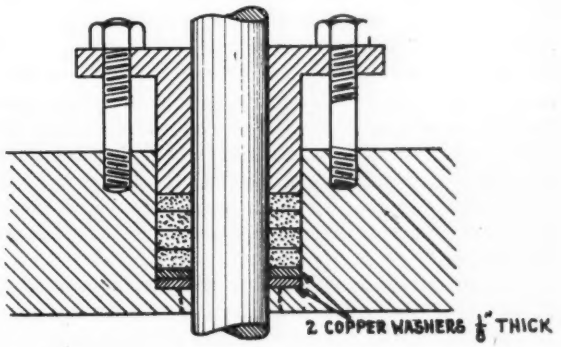
CLAMP FORCED VALVE TO ITS SEAT, AFTER THREADS ON STEM GAVE WAY

valve stem and in the bonnet were worn out. Since I did not have another valve of this size on hand, I was up against it for a while until I noticed one of the small iron machinists' clamps hanging on one of boiler room walls. I made use of this clamp at once to close the valve and keep it closed, by clamping it over the valve body and valve wheel as shown in the sketch. This did the work until another valve was obtained and installed.

Milwaukee, Wis. H. A. JAHNKE.

Washers Keep Packing Out of Pump Cylinder

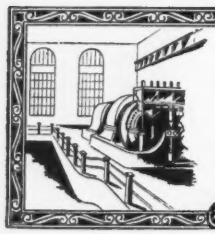
ON A DUPLEX water pump the shoulder at the bottom of the stuffing box broke away, as shown by the dotted line in the sketch, so that the packing often worked through



SPLIT WASHERS PREVENT PACKING FROM WORKING PAST SHOULDER OF STUFFING-BOX

into the cylinder. Two copper washers, each ⅛ in. thick, were placed as shown in the sketch. These washers were split so they could be put in without disconnecting the pump. They provided sufficient bearing surface for the packing and corrected the trouble.

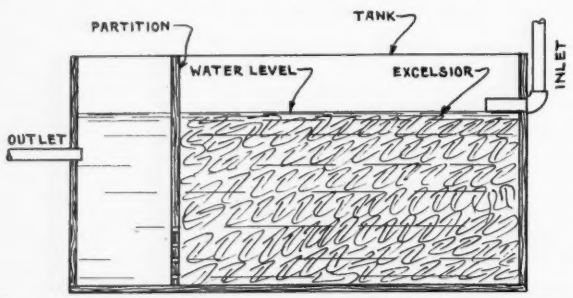
Brookline, Mass. R. B. ROWE.



QUESTIONS AND ANSWERS

Oil and Grease Extraction from Exhaust Steam

MOST OF the oil and grease that A. P. N. finds in his exhaust steam, as described in the April 1 issue, can be extracted by a simple filter. In an iron or wooden tank about 2 ft. wide, 3 ft. deep and 6 ft. long, a partition should be placed about 6 in. from one end, as shown in the sketch. Two rows of ½-in. holes should be bored in this partition about 3 in. from the bottom. Inlet and outlet pipes can be arranged as shown; then the larger space



EXCELSIOR ABSORBS OIL AND GREASE FROM WATER IN THIS SIMPLE FILTER

should be filled with excelsior, which will absorb oil from the water. A little experimenting will show how often the excelsior needs to be renewed. This will be found an unusually efficient oil extractor.

Jamestown, N. Y. C. H. WILLIAMS.

REPLYING TO A. P. N., who asked about "Oil and Grease Extraction from Exhaust Steam," April 1 issue, we suggest that the solution of his problem is the introduction of a steam separator ahead of his engine and an oil separator between the engine and the paper machine driers. Although he does not state that the steam passes through an engine before it goes to the paper machine driers and heaters, we take it for granted that such is the case, due to his mention of cylinder oil. Under these circumstances, the place to tackle the problem is at the engine rather than between the paper machine driers and the heaters.

If a steam separator of the proper type is installed just ahead of the engine, the steam furnished to the engine will be dry and it will not be necessary to use tallow in the cylinder oil. A good mineral oil can be used instead. When a mineral oil is used, it can be eliminated from the steam leaving the exhaust of the engine by an oil separator, such as the one manufactured by our company or similar device, to such a degree that it will not appear in the condensate furnished to the heater. The separator referred to will leave not more than 0.34 grains of oil per gallon in the condensate, which we do not think is enough to spot the paper.

A. P. N. is right in saying that as long as there is tallow in the oil, there is no ordinary device which will remove the oil from the water. The tallow appears to be carried in solution.

Detroit, Mich. E. M. ELIOT.

Corliss Engine Pounds After Being Overhauled

IN ANSWER to C. E. B.'s inquiry in the April 15 issue about a Corliss engine that pounds after being overhauled, I should say that his indicator cards might be improved slightly by advancing the eccentric to give admission, cut-off and release earlier and to increase compression. This would make the engine more economical in steam consumption, but may not stop the pounding, which may be caused by other things.

I would first make sure that the brasses on the crank and crosshead are not brass bound and that all bearings are tight. Knowing this engine had been overhauled, I would examine the piston rod and crosshead connections. The piston rod might be loose in the crosshead. If the trouble is not found there, remove the cylinder head and examine the piston nut, piston head and rod. I am quite sure the pounding will be here. By turning the engine over and watching the piston head and rod at the end of each stroke, it will be possible if the piston nut has backed off the rod. After the piston head has been tightened on the rod, I feel certain that the pounding will cease.

For the readers, here is a test that can be made for loose bearings on Corliss engines that will show any lost motion in any bearing on the engine. Place the engine on either dead center and unhook the wristplate rod from the wristplate. Then crack the throttle and operate the wristplate, by hand, backward and forward. This will show whether there are loose bearings anywhere on the engine.

Chicago, Ill. ERNEST KENT.

THERE ARE a number of things that might cause the pound complained of by C. E. B. in the April 15 issue. Although the noise seems to be in the crankpin connections, it may be elsewhere, due to possible looseness of some of the parts or to something being out of line.

If the pound is not due to the conditions just mentioned, then it may be due to the valve setting and steam distribution in the cylinder of the engine. Speaking in general, the diagrams produced are fairly good and if the engine operated quietly, no changes would really be required in the valve setting; but if the pound is due to the steam distribution and if one should be exceedingly critical in analyzing the diagrams accompanying C. E. B.'s letter, then since the engine in question is running at 120 r.p.m. there may not be sufficient compression at present. A little increase in lead at both ends may be beneficial; also, the

exhaust opens a trifle late at both ends. By increasing the angle of advance of the eccentric, more lead, an earlier exhaust opening and an earlier exhaust closing would be obtained. These changes would no doubt give better results and might stop the objectionable pound.

Brooklyn, N. Y. CHARLES J. MASON.

Figuring Air Compressor Speed

FREE AIR at the rate of 150 cu. ft. per min. is to be compressed to 70 lb. per sq. in. gage by a 10-in. by 12-in. motor-driven air compressor. At what speed must the compressor operate under these conditions and what size motor will be required for it? L. B.

A. Let us assume that the compressor is double-acting and that the clearance is 4 per cent.

$$\text{Ihp.} = \frac{\text{m. e. p.} \times A \times S}{66{,}000\ z}$$

in which A = area of cylinder in sq. in., S = piston speed in ft. per min., z = No. of revolutions per cycle = ½ by assumption.

Let us first determine S. This depends on the displacement, from the formula $D = \frac{A\ S}{288\ z}$. But D also equals $\frac{\text{L. P. cap.}}{E_v}$ where E_v = volumetric efficiency.

$$E_v = 1 + c - c \times R_p^{1/k}$$

$$R_p^{1/k} = (5.66)^{0.72} = 3.482$$

In this formula k is the exponent of V in adiabatic compression and since that is practically what we have here, a value of k = 1.04 has been used. R_p is the ratio of delivery to supply pressure, in lb. per sq. in. absolute and c is the per cent of clearance.

Then $E_v = 1 + 0.04 - 0.04 \times 3.482 = 0.901$. The low pressure capacity is given as 150 cu. ft. per min., therefore

$$D = \frac{150}{0.901} = 167 \text{ cu. ft. per min.}$$

But D also equals $\frac{A\ S}{288\ z} = \frac{78.54 \times S}{288 \times ½}$

Therefore $167 = \frac{78.54 \times S}{288 \times ½}$ from which S = 305 ft. per min. piston speed. Now if N is the r.p.m. and L the length of the stroke in ft. then 2LN is the piston speed.

$$\frac{2 \times 12 \times N}{12} = 305, \text{ whence } N = 153 \text{ r.p.m.}$$

$$\text{The m.e.p.} = \frac{k}{k-1} \text{ (sup. pr.) } E_v\ (R_p^{\,k-1/k} - 1)$$

$$R_p^{\,k-1/k} = (5.66)^{0.286} = 1.64$$

$$\text{m.e.p.} = \frac{1.4}{0.4} \times 14.7 \times 0.901 \times 0.64 = 29.7 \text{ lb. per sq. in.}$$

$$\text{Ihp.} = \frac{29.7 \times 78.54 \times 305}{66{,}000 \times ½} = 21.7$$

Assuming a mechanical efficiency for the machine of 80 per cent, the probable required brake hp. would be

$$\frac{21.7}{0.8} = 27.2 \text{ hp.}$$

A 30 hp. motor would probably be used here.

It is to be understood that this computation does not take into account the effect of altitude on the capacity of the compressor. At 2000 ft. above sea level, for example, the above amount of free air, 150 cu. ft., would have to be multiplied by 1.065 to get the volume of free air which, when compressed, is equivalent in effect to the given volume at sea level.

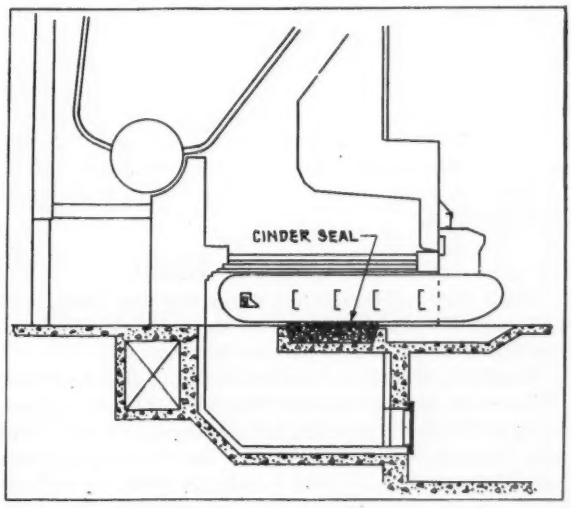
Variation in the clearance volume also makes considerable difference in the design and if the actual clearance of this compressor differs from the 4 per cent assumed, it will be necessary to revise the computation accordingly.

In a table in Kent's Mechanical Engineer's Handbook, the theoretical hp. to compress 1 cu. ft. free air per min. from atmospheric pressure to 70 lb. per sq. in gage is given as 0.146, giving an Ihp. of 21.9, which checks closely with the above calculation.

Cinder Seal Under Chain Grates Necessary

WHERE I am employed, we have chain grate stokers. By means of a high pressure water hose, ash which accumulates in front of the stoker is washed underneath and then down into the rear pit. In my opinion this is wrong. Shouldn't there be some sort of seal between the front and rear ash pits? A READER.

A. Yes. The accompanying diagram shows such a seal. Fine ash or cinders are filled in as shown until the grate must scrape through it, as it moves around. Continual siftings will assure a tight seal at all times. This is of utmost importance since the slightest draft in the furnace will cause a flow of air around the rear of the stoker.



CHAIN GRATE STOKERS NEED CINDER SEAL

This air will hug the bridgewall and pass into the tube bank without properly mixing with furnace gases. Such a seal is of even more importance with natural than with forced draft, as air needed for combustion will follow the lines of least resistance and will pass around the rear of the grate instead of through the fuel bed where it should.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Third Conference Presages Much Constructive Good

On June 21 of this year the third general conference of the International Chamber of Commerce will be held in Brussels. This conference will be attended by representatives of business interests of forty nations, who will meet to consider means to facilitate trade between countries and to further the adoption and simplification of commercial practices by which the interchange of goods internationally is carried on. Among the representatives will be bankers, economists, financiers, manufacturers, merchants and industrialists, many of whom are figures of international importance.

While it must be admitted that the Chamber has only embarked upon its career of usefulness, yet even now it has accomplished much to its credit. It was at the Rome conference of 2 yr. ago that the principles underlying the Dawes plan were discussed and adopted. The organization is the only agency by which international opinion, based on experience and the judgment of business men, can be formulated, and it is practically the only means by which we may weigh economic matters of international importance in the light of sound principles rather than as subjects for political controversy.

The forthcoming conference will discuss many international business questions in which American industry is deeply interested. For instance, it will attempt to formulate principles designed to obviate the multiple taxation of industrial enterprises operating in more than one country. International aviation, trademarks and patents, parcel post, postage rates, uniform laws governing the use of the check, the treatment of shipping, further steps in the application of the Dawes plan are a few of the more important problems coming before the conference for consideration. Not one of these questions could be solved by any one country, and experience has proved it to be worse than futile to attempt their solution by leaving them in the hands of professional politicians. American industry may look forward with interest to the third conference of the Chamber, which is now 5 yr. old, for much good should come therefrom.

A New Use for Radio

At the National Convention of the Socialist Party, held in Chicago, February 22-24, one of the speakers introduced a resolution which was, in part, as follows:

"Resolved, that this is the sense of the National Convention that it is imperative that one or more stations should be forthwith provided for the propaganda of liberal ideas, political and economic, and that ways and means should be found to provide a suitable plant or suitable plants for the radio-broadcasting of such ideas free from Wall Street control and censorship; and be it

"Resolved, that the National Committee be and is herewith empowered to secure data on the cost and expense of installing and maintaining a suitable radio-broadcasting station, and to enter into contracts for the necessary equipment, and be it further . . ."

Radio is our greatest means of publicity. Publicity is light shed on every angle of a question. Propaganda is light concentrated on only one angle. Radio should be kept free for true publicity—be it religious, political, economic or social subjects. Using radio for propaganda purposes will make its usefulness short-lived.

What Is Good Lighting and How Can It Be Obtained?

Within the last few months, many articles have been written on the subject of industrial lighting and the astonishing need for better illumination, as indicated by the percentage of industrial workers having defective eyesight.

Just what constitutes adequate illumination has recently been determined by the Illuminating Engineering Society. Their recommendations are in accordance with the existing laws of New York, Pennsylvania, Ohio, Oregon and Washington, and are:

CLASS OF WORK OR SPACE	RECOMMENDED FOOT-CANDLES
Roadways and yard thoroughfares	0.25
Stairways, aisles, storage spaces, etc	0.70
Rough manufacturing (foundry or assembly work, or rough bench work having no fine detail)	3.5
Fine manufacturing (lathe, pattern, or any fine detail work)	6.5
Clerical work (filing, typewriting, billing, etc.)	6.0
Special work (drafting, engraving, watchmaking, etc.)	15.0

Anyone who desires to be sure that existing illumination is adequate should prove himself with a foot-candle meter. The instruments are small, compact and inexpensive, and measure the illumination as readily and accurately as a thermometer will register the temperature.

A simple, yet efficient checkup on lighting systems is as follows:

1. Are old-fashioned drop cords used? These are not only lamp breakers but dangerous.

2. Are there any bare lamps? Such lamps waste light, cause eye-strain, create glare and should not be tolerated.

3. What is the distance between units? Under ordinary circumstances 10 to 15 ft. is probably the best practice.

4. Are clear lamps used in open shades? Shades or reflectors open at the bottom should not be used with clear lamps which come in the line of vision. Replace with bowl-enameled lamps.

5. Are lamps too small? 200-watt lamps ordinarily provide the most light with the least consumption of energy, considering installation cost, reflectors, etc. Bigger lights have heavier filaments, however, and can be operated at a high filament temperature, giving more light per watt of energy consumed.

6. Are there sharp shadows? Any object, held over a white surface, should cast only a faint, hazy shadow.

7. Are the shades dirty? Dusty or dirty lamps or reflectors have been known to absorb as high as 68 per cent of the light produced. Monthly cleaning is a profitable practice.

8. Are there any dead lamps or empty sockets? The value of the most carefully planned lighting system can be nullified by dead lamps or empty sockets.

Send Your Boy to Camp

If you are fortunate enough to have a regular, red-blooded, American boy, age 17 to 24, and send him to a Citizen's Military Training Camp this summer, he will come back a finer, truer, more tolerant American—a better citizen.

No expense is involved, since the Government pays all expenses of transportation, uniforms, food, medical attention, laundry, etc. There is no obligation imposed on your son except the promise to go to camp, receive the training and behave himself.

You have the definite knowledge that while at camp for the 30-day period, your son is in the hands of experts in the training of young men and that he is well cared for. He will be required to pass a critical physical examination, after which he will be informed by competent medical officers of any minor defects that may be removed or overcome by proper attention to the instructions which they furnish. He will live for 30 days in an atmosphere permeated with the spirit of service to country and where the principles of truth, honor and good sportsmanship are taught and instilled by precept and example. Character building is the main objective of these summer camps and your son will be taught without harshness or severity. Unconsciously, he will be led into habits of obedience, promptitude, neatness and cleanliness of mind and body.

Short talks will be given your boy on such subjects as: The Meaning of Liberty, Constitutional Government, National Defense, Independence, Union, Justice, and Welfare. Round-table discussions, directed by competent officers, will be held on topics such as: The Constitution and How It Can be Amended, Our Government and How It Functions, What the Army Does Besides Fight, Obedience to Law—Police Regulations, Fire Prevention, etc. Lectures, illustrated with slides or motion pictures, will be given him on: Boston—the Home of Patriots, Philadelphia—The Cradle of Liberty, New York—The Gateway to America, Chicago—The Gateway to the West, Washington—Our National Capital, West Point—The United States Military Academy. Patriotic motion pictures, such as Betsy Ross, Is America Worth Saving, and Powder River, will be shown.

You will be pleased at what 30 days of regular work, regular sleep, and regular play in the great outdoors will do for your son. It is your privilege to enroll him.

Currency Turnover

According to the New York Trust Co., the volume of debits to individual bank accounts was 99 times the actual money in circulation, during 1924. The figures show that the total of all classes of financing in 1924 (exclusive of Government securities) was over 6 1/3 billion dollars whereas the total money in circulation (Jan. 1, 1925) was less than 5 billions of dollars.

With this circulation of about 5 billion dollars, the resources of the banks at the close of last year totaled over 55 billions, while individual bank deposits were nearly 43 billions, loans and discounts being over 31 billions.

These figures, a comparison of the actual money in circulation with the volume of transactions or credits, indicate better than anything else the rapidity of turnover in currency. Indeed, during the past year, currency turnover was so rapid that none of it stopped with the writer long enough to form an acquaintance. All the money that stayed with the writer last year could be poured molten down his throat without the slightest damage—to either the money or the throat.

Interconnection Rapidly Developing

Interconnection is a scheme for the co-ordination of all major central station power units over a wide area. It is merely the application of common sense principles and sound business practices to power production problems in manufacturing areas of the United States. The outstanding advantages to be gained by linking together the individual electric power producers is to afford the hydro-electric plant an opportunity to market the surplus power developed during flood times into areas served only by steam plants, as well as to protect those depending upon hydro stations in time of drought. Another advantage will be the cheapening of production costs to an extent where the individual factory can often get cheaper power.

Most outstanding has been the development in the electric power producing field; 25 yr. ago the production stood at about 300,000 hp., while today it is in excess of 10 millions—an increase of over 30 times. According to the U. S. Geological Survey, the yearly average of mean daily production in millions of kilowatt hours, is: 1919, 107; 1920, 112; 1921, 120; 1922, 131; 1923, 153; 1924, 166.

When You Refuse to See a Salesman You Overlook a Rich Source of Ideas

How many salesmen called upon you last year? A hundred? If so, you had one hundred opportunities to enrich yourself with business information—free.

Generally speaking, ideas cost a great deal of money, yet without them we make no progress. Sound business information is usually to be found only at conventions, associations, or other sources that prove more or less expensive. But such information is a business necessity.

If you could travel, as salesmen do, visiting plant superintendents and engineers in distant cities, you could gather an equally rich and varied fund of practical knowledge. But you cannot spare the time. Therefore it pays to keep your ears open and your mood receptive when a salesman calls.

You may not need his goods, but you need all the information you can get out of him. Ask him questions. Listen to him. If you treat salesmen courteously you will gain many practical ideas.

Getting "Back to Normalcy"

In 1917 the payments made by the railroads for loss and damage claims totaled $35,000,000. This figure increased rapidly, under government ownership during the war, until it had reached nearly $120,000,000 in 1920. Since the return of the railroads to private management, however, the claims have again receded until in 1924 the payments reached the normal level of $36,000,000.

In justice to federal control, however, it must be said that as the amounts paid through loss and damage claims are determined somewhat by the market value of commodities, a correct understanding of the increase or decrease must take into account the prevailing market values of the various years. The radical decrease in claims entered and paid shows conclusively, however, the increased efficiency that has been brought about during the past 4 yr.

EDITORIAL COMMENT

Midwest Power Show Fills a Need

Throughout the entire country, there has been concerted effort to reduce the cost of power, particularly during and since the war. This drive has met with considerable success in the face of many difficulties. A review of statistics covering various industries will show that the amount of fuel used today is considerably less for each unit of power output than it was five years ago.

This success in the more efficient use of fuel cannot be attributed to any one cause. We must give credit first of all to the designers, builders and manufacturers of power plant equipment for their better understanding of the problems involved and their ability to meet the demands placed upon them. We must not neglect, however, to give due credit to the thousands of men in the power plants of the country who, for hours every day, maintain conditions specified by the designer of the plant which a few years ago would have been impossible. In the end, we must depend upon these operators of power plants for increase in efficiency and every agency which will aid them in their tasks should have the support of the entire industry.

At the time of the spring meeting of the American Society of Mechanical Engineers, May 18 to 21, there will be held in Milwaukee an exhibit of power equipment. In reality this may be looked upon as a graduate school where the instructors are the specialists of the country and the equipment the very last word in design. Most of the equipment, which will be placed on exhibit, will be taken from the stock at the factory, some will be special designs ready for shipment to a new power plant.

This is the first exhibit of the kind to be held in the Middle West and the opportunity offered to the engineers of this section of the country to become intimately acquainted with the design and construction of modern equipment should not be passed by. The inspiration an engineer receives to better his own plant, by learning what others are doing and examining the equipment with which they work, has more than a dollars and cents value. We have no doubt that the results of this power show will reflect in higher economy in the power plants of the Middle West.

Success Through Enthusiasm

One tree does not make a forest and, in like manner, one man does not make an organization. These facts are often lost sight of by those in authority. That there is sales work to be done within an organization as well as without often seems to be overlooked.

It is, of course, obvious that every organization needs a leader. Somebody must be capable of assuming the initiative but, if that man cannot impart his spirit to his immediate subordinates and they, in turn, pass it on to the employes, it is certain that success cannot be attained.

Here and there in the power plant field we find interesting examples of such leadership, which has inspired enthusiasm all along the line and, in those cases, we find the successful organization towards which every executive aspires.

One interesting example of this type of leadership is exemplified by the rejuvenation of a great mid-western utility. Six years ago the present management assumed control. At that time, expenses were mounting skyward and income was on the decline. Labor turnover was enormous and credit could not be had from the banks. Investors had lost faith in the company, as was evidenced by the stock market quotations, and on top of all this the customers were thoroughly dissatisfied with the service.

With the advent of the new management came a change in the attitude and policy towards not only the public but also the employes. The first move to be made was to sell faith in the company to the rank and file of the organization. It was virtually necessary to capture the organization by instilling in it the same confidence and belief in the company that was held by the new management.

This was accomplished first by frequently calling in all the department heads and enthusing them so that they would pass the spirit on down the line. It was not long before the tide began to turn. Those within the organization who doubted the ability of the company to pull through began to gain confidence. In a short time all were working with enthusiasm to remedy the complaints made by the public. Here was an executive who had behind him a crowd of fellows who believed not only in him but in the business. Through their co-operation the public was better served and thus this company ceased to be a topliner on the front pages of the daily press.

Today, the stock market shows its confidence in that company by an increase of 400 per cent in the price quotation of its securities. The public grouch has disappeared and the volume of business has increased 50 per cent.

That tells the story. To sum it up, it was necessary to enthuse the organization before success could be attained. This having been done, the rest of the job was comparatively easy. What is true of this mid-western company is also true of industry in general. Get your organization to believe in you and your purposes, have it share your enthusiasm and success will be won.

Power Plant Apprentices

In many ways the apprentice system, as it developed in Europe from the guild system and as it was afterwards transplanted to this country in modified form, was an unwieldy, inefficient and time-wasting process. Nevertheless, the system did one important thing; it produced workmen trained by long practice in the manual processes of their various trades and it bred in them a realization of the importance of good judgment and honest workmanship.

In the power plant, however, the apprenticeship plan has seldom been used. Here, more than in any other branch of mechanical work, the novice has been left to drift blindly along by himself, picking up scattered bits of theory here and there, getting fixed in his mind a smat-

tering of ideas that often turned out later to be quite erroneous, learning the particular operating kinks of his own plant, with little about fundamental principles, and ending usually as a limited, under-developed operator.

Yet every engineer will agree that the operation of modern power plant machinery requires, in the highest degree, the proper co-ordination of the work of brain and hand. Moreover, in an emergency, the principal requirement for the operator is that he shall do something. It is not enough for him simply to say that the equipment is not running well and that it ought to be fixed. His brain must tell him that certain definite causes are producing the bad effects and must then direct him to act to remove those causes as quickly as possible.

It must be apparent that, to accomplish this result, the old, haphazard method of allowing plant engineers to be educated in the school of hard knocks is too wasteful for present-day methods. Some of our plants realize this. We commented some time ago on the interesting method used by a large southern public utility company to insure the training and promotion of its employes. In this issue is an interesting article by H. A. Frommelt, telling how a large machinery manufacturer has developed an apprenticeship course designed to give the novice some knowledge of power plant work and machine shop work, from both the theoretical and the practical standpoints.

Such cases, however, are the exception in power plant work, although they are quite common in the production departments of industry. Every one of the recognized engineering colleges of the country has some scheme whereby its men can receive training in industry. The training courses of General Electric Co. and the Westinghouse Electric & Mfg. Co. are well known. But in the power plant, such training has been too long neglected.

No reason exists why the principles employed in training men for the industrial departments cannot be applied to the most vital spot in the organization—the place where the motive power for the whole plant originates. Certainly the experiences of the few plants that have tried the plan have shown its desirability. There should be more of it in the power plant field.

Off Duty

There is a certain little animal which roams the woods and prairies of the temperate zone, which because it possesses certain peculiar natural powers of protection has come into wide disrepute. It is not a harmful animal in the usual sense of the word, neither is it unattractive to the eye, in fact, its fur is used extensively for women's wearing apparel, yet the mere mention of this innocent little creature in respectable circles is enough to make everybody blush. In fact, we have heard the skunk referred to as a little "white and black pussy cat" in order to avoid the inelegance of recalling his odor to mind. The skunk is the victim of our scorn for our own sense of smell.

Considering the conspicuous location of our nose on our anatomy it is strange that we should regard it with such utter contempt. We are endowed with five perfectly good senses but in spite of the fact that we are always on the lookout for a sixth, we practically ignore one of the five we have—the sense of smell, how we scorn it!

Now on the face of it, this attitude toward the sense of smell is silly. Insofar as the odors of flowers and fruits are concerned, yes, we admit we possess a sense of smell but outside of that practically every other odor is taboo.

Certainly, we don't display the same attitude toward our other senses; the best of us does not close his eyes when he sees an unpleasant sight, or stop up his ears when he hears an unpleasant sound. If we did we should be walking around with our eyes closed and our fingers in our ears half of the time.

The nose, as Elwood Hendrick has pointed out in a little book called 'Percolator Papers" is an organ equipped for the acquisition of knowledge, as complex as the human eye, entering into the most active part of the brain, and we, marveling at the wonderful advances of human knowledge, neglect it, scorn it, in fact we politely deny that there is such a thing as an individual odor to ourselves and our friends. Yet this is a fact, our odors are as distinct and personal as are our countenances. Every dog knows this and unless his olfactory organs are atrophied he makes good use of it.

That ridiculous song title, "We Feed Our Baby Garlic so We Can Find Her in the Dark," carries with it an indication of a convenience our sense of smell would give us if fully developed. All of us, because of the processes of metabolism, exude odors which are characteristic of ourselves, even more so perhaps than our facial expression. These odors, if we could recognize them, would aid us greatly in confirming our vision. Imagine, being able to smell unwelcome callers before they opened the door, or, on the other hand, think of how pleasant it would be if in a crowded subway train you were able to smell an old acquaintance at the other end of the car.

"Why, my dear Harry!" you would exclaim when you reached him. "How are you? I smelled you the instant I came in the door but could not see you because of the crowd."

With the present state of the art of smelling, however, we can do nothing like this. Except by dogs, the subject remains unknown. Dogs with their highly developed olfactory organs can detect the minute differences in personal odors and they never fail to confirm their vision when they meet their masters by a nose investigation.

The sense of smell as an aid to memory is not entirely unknown. How often does a single whiff of some characteristic odor bring back memories which a moment previous were entirely forgotten. It is said that every impression in the life of a human being is permanently recorded in the brain cells. Yet, of the millions of impressions, how few we actually remember. Think of how wonderful it would be then, if by some orderly process we could associate our acts and impression with some characteristic odor and in this way recall to mind any impression, merely by smelling up and down the scale of odors.

A pipe dream? Well, maybe; still pipe dreams are sometimes excellent sources of inspiration and we need a little inspiration along these lines. Little has been done. The perfumers and soapmakers, to be sure, are educating us in the art of smelling to a limited extent but, as Newton put it, "the immense ocean of truth still lies before us unexplored."

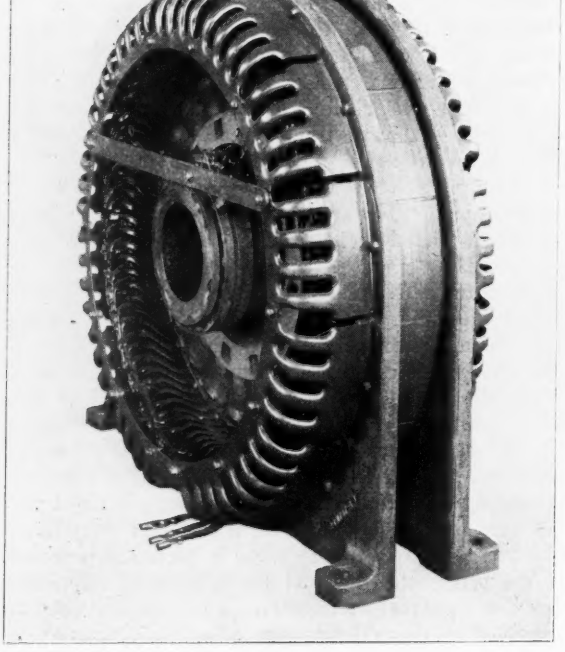
It is possible that some day far in the future the sense of smell will be more highly regarded and will reach a stage of development comparable to the development of the sense of sight and hearing today.

In the meantime the principal use of our noses will be to act as a pivot on which to balance a pair of spectacles or to serve as an indicator showing our ability to violate the 18th amendment.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

General Electric Develops New Synchronous Motor

FOR USE in connection with the driving of slow speed reciprocating compressors for compressed air or refrigeration service, the General Electric Co. of Schenectady has recently developed a new type of synchronous motor.



STATOR AND ROTOR OF TYPE TS-22 POLE 50 HP., 1.0 P. F., 3-PHASE, 60-CYCLE, 440-V., 327-R.P.M. SYNCHRONOUS MOTOR

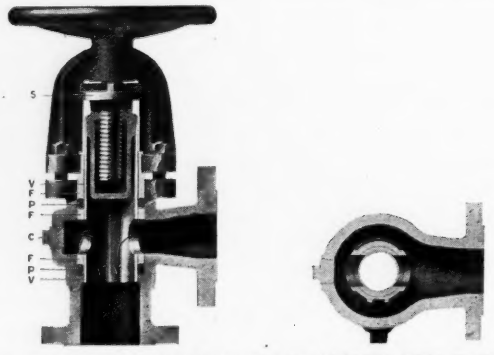
This motor, bearing the designation TS, is being built in more than 300 standard ratings larger than 20 hp. at 60-cycle synchronous speeds between 72 and 450 r.p.m. Due to the nature of compressor drive, these motors are given a maximum rating at a temperature rise of 50 deg. C.

Other synchronous motors have been quite successfully applied to this slow speed service for a number of years. During that time the definite requirements of compressor drive have been the subject of extensive study and investigation. The results of these tests have now been incorporated in the TS type of motor, embodying all the necessary and desirable characteristics for this class of service.

Since the general adoption of electrical equipment in place of slow speed oil and steam engines for driving compressors, the direct-connected synchronous motor has been popularly accepted for this service in preference to the belted induction motor, because of its great saving in floor space and improvement of power factor. To strengthen and further justify this preference and to produce the most desirable drive for slow speed compressors, the TS motor has been carefully designed to obtain: (1) extreme simplicity of the starting operation; (2) starting conditions satisfactory to the power company; (3) adequate torques; (4) efficient operation, and (5) minimum flywheel requirements.

New Seatless Balanced Blowoff Valve

AMONG recent developments to meet the requirements of high pressure boiler practice is the Yarway Type "B" Seatless Blowoff Valve, which has features differing



BY PROVIDING AN ANNULAR SPACE AROUND THE PLUNGER THE YARWAY BLOWOFF VALVE IS MADE SUITABLE FOR 650 LB. SERVICE

somewhat from former designs made by the Yarnall-Waring Co. The principal improvement is the provision of an annular space in the body, which distributes the pressure around the entire plug or piston, balancing it completely and making it easy to operate. This design permits two openings to the plug and thus shortens the travel of the plunger, making the valve quick to operate.

Another advantage of this design is the provision of a plug opposite the pipe connection to the boiler which permits cleaning out the blowoff pipe with a rod, inserted through the ports, without disturbing the valve connections. As in former designs, this valve has packing rings above and below the ports which are automatically tightened by the shoulder on the valve plunger pressing against the upper follower gland when the handwheel is turned down hard.

These valves are made for service on boilers carrying pressures as high as 650 lb. and the dimensions conform to the regular A. S. M. E. code for extra-heavy fittings.

Midwest Engineering Exposition to Be Held in Chicago

DEFINITE plans are announced and details are being perfected for a Chicago Power Show to be held in the American Furniture Mart, Jan. 26 to 30, 1926. It will be organized by the Midwest Engineering Exposition, Inc., of which the incorporators are Edward P. Rich, Secretary of Neiler, Rich & Co., James D. Cunningham, President of Republic Flow Meters Co., and George E. Pfisterer, Western Manager of Green Fuel Economizer Co.

The exhibit will be housed in the large space, 300 by 200 ft. on the first floor of the Mart, entrance being through the marble and walnut lobby, 100 ft. long, which is an approach worthy and fitting for it. Exhibits will, so far as possible, be arranged in classification so that visitors may readily find and inspect the entire display of any product in which they are specially interested.

Spaces of various sizes are available, from 10 by 10 ft. up to 10 by 20 ft., 304 booths being laid out on the plan. Exhibit spaces will be supplied with electric current, water and drainage and can have steam connections, if desired. Telephone, telegraph and messenger service are available in the building which is easily reached by street car and bus service, only a few minutes ride from the loop.

Engineering meetings will be held during the exposition in the assembly hall, seating 1200 people, to which ample express elevator service will be supplied. Also, inspection trips will be arranged to points of engineering interest in Chicago by the various societies which will hold meetings.

For exhibitors, the facilities, restaurant and rooms of the Furniture Club will be made available during the exposition, while cafeteria and table service will be provided for visitors on the 16th floor, to which two large express elevators give quick transport.

It is expected that 15,000 engineers will visit the show each day, a number for which the facilities are entirely adequate.

The exposition has the backing of representative engineers and organizations throughout the Middle West as well as of the Chicago Association of Commerce, which ensures its success as well as wide interest and attendance from all sections within a 500-mile radius.

Further information will be given as plans progress. Details as to spaces and prices can be had from the management of Midwest Engineering Exposition, Inc., 517 Monadnock Block, Chicago.

Imita-Gold, a New Alloy

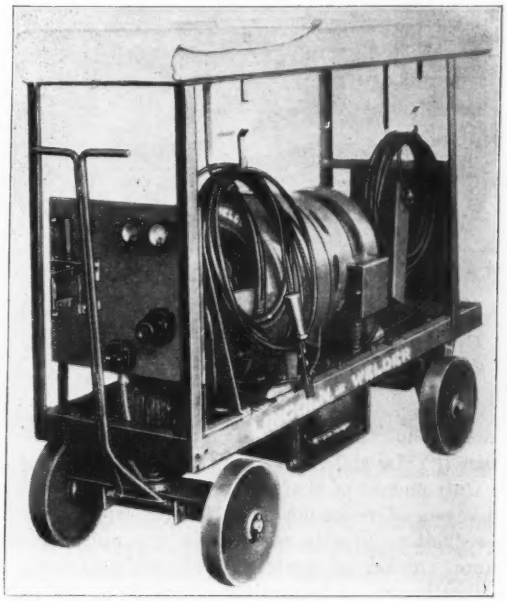
UNDER the trade name of Imita-Gold, a new metal has been placed on the market by the Imita-Gold Corporation, West Haven, Conn. The metal has the color and luster of 18-carat gold and the strength of high carbon steel. As it is unaffected by acids, alkalies and sea water and is easy to machine, it should have a wide use in the pumping field alone.

Imita-Gold, it is claimed, needs no electroplating to bring out its luster and requires little polishing to keep it bright. Electrical and heat conductivities are about 90 per cent of pure copper. Weight per cubic inch is the same as cast iron. The tensile strength averages 76,000 lb. per sq. in. Elongation, elasticity and yield point are almost identical with 40 per cent carbon steel. The metal can be cast, drawn, forged and welded.

This metal cannot be remelted without losing its characteristics. An analysis would give only the amount of copper and aluminum which by themselves make an alloy of little strength and luster. By the process employed, copper and aluminum can be combined into a homogeneous alloy without pores or blow holes. For this reason it becomes an excellent bearing metal of great strength. An added point of interest is that the process induces a natural lubricant into the metal and a bearing can be run dry at intervals without undue heating or burning out.

Portable Electric Welder

MANY PRACTICAL considerations have been incorporated in a new electric welder which has recently been put out by the Lincoln Electric Co., Cleveland, O. All



STEEL FRAME EXTENDS OUT BEYOND THE APPARATUS MOUNTED ON IT

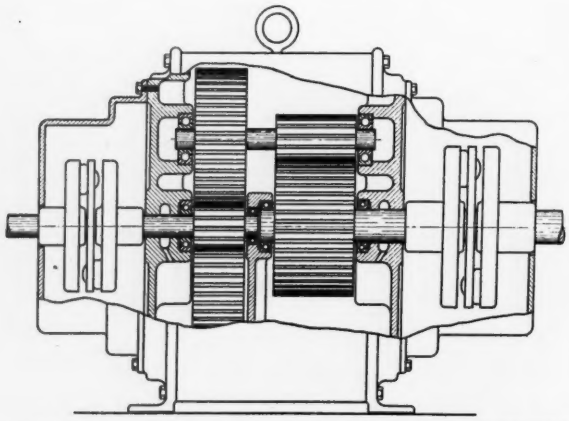
the electrical apparatus is mounted on a steel frame truck, the width of which is but 21 in. This, it is considered, will be an advantage where the welder is to be used in shops or on repair jobs where passageways are narrow. The center of gravity of the machine is low, therefore it is not easily turned over when being moved from one job to another.

The structural frame of the truck extends out beyond the equipment mounted on it so that it is highly improbable that the welder would be damaged by careless handling of the truck. Through the use of large roller bearing wheels the unit is made easily portable. The machine is provided with a weatherproof cover which can be thrown back readily, but which will provide protection from the weather when required. A push button starter, tool box, spring controlled handle which is out of the way when not in use, cable hooks and total light weight are some of the other features.

Increased speed of this machine is made possible through the use of the "Stable-Arc," which provides a steady and uninterrupted flow of heat.

Ball Bearing Spur Gear Reducer

SHAFTS ON BALL bearings, the housing oil-tight with full and clear space inside without any obstructions such as partitions for supporting countershafts or gears on stationary or revolving disks with overhung pins, are features of a speed reducer made by Albaugh-Dover Mfg. Co., Chicago, Ill. It is usually comprised of three countershafts uniformly spaced about the center line of drive shafts which carries the change speed gears between the driving and the driven shafts. The three countershafts extend entirely across the length of the reducer housing between the end walls and are journaled in the end walls of the casing on their ball bearings.



THREE COUNTERSHAFTS ARE UNIFORMLY SPACED ABOUT THE CENTER LINE OF THE DRIVE SHAFTS

Transmission gears are of high grade material to minimize the size and reduce the total weight of the entire unit. Only one set of shafts is required for single, double or triple sets of reduction gears for the largest ratios of speed reductions usually required in one unit, making a minimum number of parts and all self-contained with equal distribution of transmission load from the driving to the driven shafts, all self-oiled from the same reservoir of oil in the full size bottom of the usually circular gear housing.

Extreme reduction is attained with maximum power in the transmission by having a revolving internal gear meshing with pinions on the projected ends of the countershafts outside of the main housing. The internal gear together with the shaft couplings connected to the driving and the driven ends of the shafts are enclosed by attached housing extensions which are both safety covers and protection to the gears and bearings from dust as well as providing a covering for safety. These features are exclusive and new in these gear reducers. There is no loss in efficiency due to the usual multiplicity of bearings and bearing surfaces; there are no inside bearings that may become either oil clogged or run dry through inability to inspect.

Any ratio desired of speed change between driving motor and driven machine may be effected within the limits of gear ratios, with either increased or decreased final drive speed to meet transmission requirements on the final drive. These reducers may be run to the right hand or left hand with equal facility by reversing the direction of driving motor and will provide equal results in the transmission of power running constantly in the same direction or alternately reversing. The drive shaft and the driven shaft always revolve in the same direction of rotation with any ratio of reduction.

These reducers are furnished for direct connected shaft drives to conveyors or elevators and are to be located between the motor and the driven unit occupying small space and eliminating excessive supports.

Improvements to V-Notch Meter

DIFFERENCE IN temperature between water in the float chamber and the water in the still water chamber from which the water flows over a V-notch may result in inaccurate register of the meter. If the water in the float chamber is cooler than the water in the still water chamber, it will not stand at as high a level and the meter will, therefore, register low. This has been found to occur even when the float chamber was contained within the main meter tank or chamber. An outside float chamber

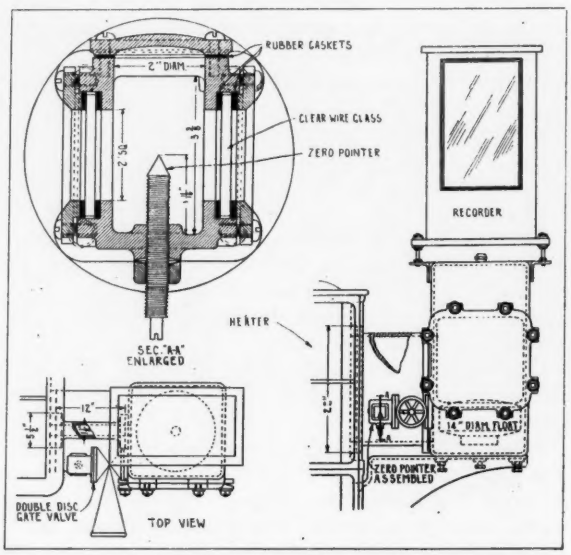


FIG. 1. DETAILS SHOWING CONSTRUCTION AND LOCATION OF ZERO LEVEL POINTER

is also an advantage because the water in the float chamber will be colder than the water in the meter chamber, so that it will not boil up due to a sudden reduction in pressure. The arrangement finally adopted by the Cochrane Corp. is to connect the float chamber to the still water chamber at all levels, that is, by the use of a deep narrow channel. This permits placing the float chamber entirely outside of the heater chamber, which is sometimes desirable.

Use of the channel has the further advantage that periodic oscillation or surging is not so likely to be set up as where the bottom of the float chamber is connected to the still water chamber by a small bore pipe. The reason for this is that the velocity of flow due to a small bore pipe, whenever there is a difference in level between the two chambers, results in a considerable amount of energy being converted into energy of motion, the effect of which is to cause over-travel. In this way the level will keep going

up and down, sometimes for a long period. With the vertical channel connection this does not occur to any extent.

Accompanying sketches show the same idea applied to the little outside chamber in which is placed the zero level pointer. The purpose of this zero level pointer is to make it possible to set the recorder to zero when the meter is filled with hot water and when it would be impossible to see by direct inspection whether or not the water was actually at the apex of the notch. The zero pointer should be in an outside transparent enclosure. Originally a glass tube was used, which was connected at the top and bottom to the still water chamber. This arrangement obviously had the same defect as the outside float chamber, since the water in the tube became chilled and did not stand as high as the water in the still water chamber. It had the further defect that slugs of water occasionally condensed in the vapor connection at the top of the tube, giving rise to false readings.

New types of outside zero pointer chambers are connected to the still water chamber through a large gate valve, the center of which is at the zero level. The water can, therefore, flow back and forth freely and it is assured

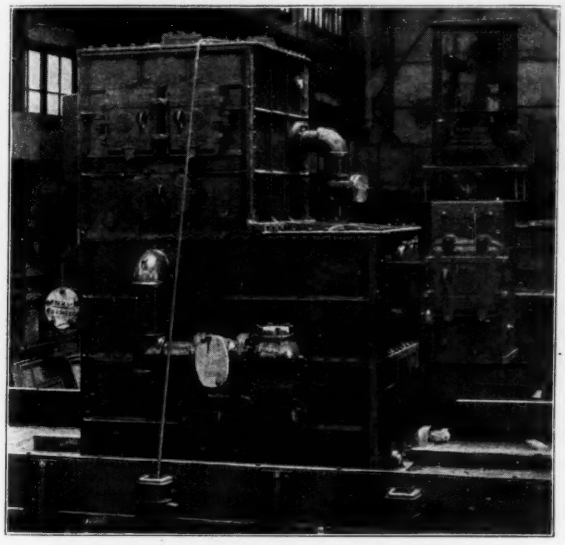


FIG. 2. FEED-WATER HEATER AND V-NOTCH METER ASSEMBLED WITH CONNECTING CHANNEL

that the level outside is the same as the level inside. The zero pointer chamber as actually constructed has two glass windows. It also has a large size handhole at the top, through which the inner sides of the glass plates are accessible for cleaning off oil or other accumulations.

THE COMMONWEALTH Edison Co. recently awarded to the Westinghouse Electric & Mfg. Co., a contract for the world's largest frequency converter set. This set has a capacity of 40,000 kv.a. and will be used for tying together the Commonwealth Edison Co.'s 60-cycle and 25-cycle systems.

The latest refinements in design will be incorporated in this set and it will be equipped with a motor operated frame rotating device, a direct-connected induction starting motor, and two direct-connected exciters.

Francis Hodgkinson Presented With Cresson Medal

IN RECOGNITION of his achievements in the field of steam turbine design and construction, Francis Hodgkinson, chief engineer of the South Philadelphia Works of the Westinghouse Electric & Mfg. Co., was presented with the Elliott Cresson gold medal by the Franklin Institute, Philadelphia, Pa., at its monthly meeting at the Institute Building, April 15. The presentation was made by Dr. William C. L. Eglin, president of the institution, with a commendatory and appropriate address, outlining in brief the accomplishments of Mr. Hodgkinson in his field of activity.

Mr. Hodgkinson was born in England and received his early education at the Royal Naval School at New Cross,

FRANCIS HODGKINSON HONORED BY FRANKLIN INSTITUTE

London, completing the course in 1882. Three years later he joined the organization of C. A. Parsons & Co., steam turbine builders, continuing with this organization in various capacities until 1890, at which time he was acting as superintendent of field work. Following, he joined the Chilean Navy and served during the civil war; later, in 1892, he became engineer for the electric light and telephone companies at Lima, Peru.

In 1894, Mr. Hodgkinson returned to England and resumed his connection with the Parsons company as general foreman of the erecting and fitting shops. The following year, the Westinghouse Machine Co., East Pittsburgh, Pa., the original name of the turbine-building division of the Westinghouse Electric & Mfg. Co., obtained the American rights for the manufacture of Parsons type steam turbines, and in 1896, Mr. Hodgkinson became associated with the Westinghouse organization, in charge of the engineering and designing of the Parsons units. He has continued in this position from that time and, since 1916, has also acted as chief engineer in charge of the engineering departments at the South Philadelphia works.

The first commercial steam turbines in this country used with alternating-current generators, were designed and perfected by Mr. Hodgkinson, installed in 1899 and are still in regular commercial service. Practically all of the commercial steam turbines constructed by the Westinghouse company have been originated largely by him and designed under his supervision.

News Notes

A NEW BRANCH OFFICE has recently been opened at 327 Washington Ave., Scranton, Pa., by Warren Webster & Co., of Camden, N. J. This Scranton office is under the management of C. S. Dean.

H. E. NEUBAUER, formerly assistant chief engineer of the Buffalo Foundry & Machine Co., later vice-president of O. S. Sleeper Co., Inc., has become associated with the Chemical & Vacuum Machinery Co., Inc., as chief engineer.

JENKINS BROS. has purchased the good will, stock and accounts of H. A. Rogers Co. of New York City. The latter company has for 55 yr. handled the product of John Moncrieff, Ltd., Perth, Scotland, makers of gage glasses. William A. Tucker, vice-president and treasurer of H. A. Rogers Co., will become associated with Jenkins Bros.

THE BROWN HOISTING MACHINERY CO., of Cleveland, Ohio, announces the following appointments in its sales organization; J. P. Chase, sales manager; J. F. Poland, manager of the Chicago office; E. W. Taylor, manager of the Pittsburgh office. In addition to his duties as sales manager, Mr. Chase will be in charge of the Cleveland sales division.

DUQUESNE LIGHT CO. of Pittsburgh, Pa., is extending a cordial invitation to engineers to visit its great plants, Colfax, located near Cheswick and Brunot Island on the West End Street car routes. Certainly these plants will well repay a visit by anybody who can avail himself of the privilege. Cards of admission can be secured at the company's general office, 435 Sixth Ave., Pittsburgh.

ANNOUNCEMENT COMES to us of an arrangement that has recently been effected between Carels Brothers, of Ghent, Belgium, and the Ingersoll-Rand Co., of New York City, whereby the Belgian concern will have the right to manufacture the Ingersoll-Rand solid injection type of oil engine. Carels Brothers, organized in 1875, have long been prominent in the industrial life of Belgium and were among the first of the European licensees to work under the Diesel patents.

FOURTEEN DISTRICT representatives have recently been appointed by the O. E. Frank Heater and Engineering Co., Buffalo, N. Y. They are as follows: Geo. L. Fitz, New York City; Oscar J. West, Chicago; Haynes Selling Co., Inc., Philadelphia; The Coon-De Visser Co., Detroit; H. P. Rodgers, Cleveland; Power Equipment Co., Pittsburgh; Vance and Vance, Baltimore, Washington, Richmond and Roanoke; H. S. Hall, Inc., Charlotte; Irvin H. Geiger, Harrisburg; Steam Plant Equipment Co., Kansas City and M. J. Haley, San Francisco.

TWO HORIZONTAL WATERWHEEL generators rated at 28,050 kw. each, the largest horizontal units ever made, have been ordered for the Sao Paulo Tramway, Light & Power Co. of Brazil from the International General Electric Co. The generators, purchased by the Canadian and General Finance Corp., Ltd., are rated 33,000 kv-a., 85 per cent power factor, 360 r.p.m., 11,000 v., 60 cycles, 3 phase. They will be driven by Pelton double overhung waterwheels, operating under a head of about 2300 feet. The shafts and bearings will be supplied by the Pelton Co. In addition to the waterwheel generators, the order calls for seven 11,000-kv.a., 88,000-11,000-v., single-phase, 60-cycle, water-cooled transformers.

The two generators ordered earlier this year are for the Hayakawa Co., a subsidiary of the Toho Co., and will be installed at Kawasaki, Japan. They have similar ratings, except that they are for 50-cycle generation.

ARTHUR D. BLANCHARD, formerly plant engineer of the Crocker-Wheeler Co., has been advanced from the engineering department of Chas. Cory & Son, Inc., to the industrial sales staff. He will be located in the New York office.

GIFFORD-WOOD CO., Hudson, N. Y., increased its capitalization by a special issue of common stock on April 1. All the stock thus made available was at once subscribed to by employes. This plan was put into effect by the company in order to allow the employes to benefit by their own efforts.

Catalog Notes

WARREN WEBSTER & CO., of Camden, N. J., has issued a folder which points out the application of its heating systems to various types of buildings.

BULLETINS 105 AND 106, recently issued by the Poole Engineering and Machine Co. of Baltimore, Maryland, describe the Poole type "K" and type "H" Speed Transformers for increasing and decreasing speeds. These bulletins illustrate and describe in detail the construction and application of these gear units.

BULLETIN 425 JUST issued by the Esterline-Angus Co., of Indianapolis, Ind., describes the Esterline-Angus Twin Type Graphic Meter. This is a new meter in which any two standard elements can be built, in which either strip charts or daily charts can be used, which occupies 30 per cent less switchboard space, and which gives two records accurately synchronized as to time.

GOULDS MANUFACTURING CO., of Seneca Falls, N. Y., is sending out on request a 20-page report showing results attained in pumping oil with centrifugal pumps at the Los Angeles refinery of the Union Oil Co., of California. It includes 18 charts showing performance of single and multi-stage pumps on fluids ranging from gasoline to oils of 7000 Saybolt viscosity. This report can be had by writing to E. S. Jenison, sales manager of the Goulds Co.

"ADSCO HEATING RADIATES COMFORT" is the title of Booklet No. 181 just received from the American District Steam Co. of Tonawanda, N. Y. This book tells how the Adsco system of atmospheric steam heating functions and how it is possible with this system to effect a saving in the fuel consumption. The book is well illustrated and in addition to a number of explanatory diagrams shows various buildings in which this system of heating has been installed.

LINK-BELT RIVETLESS CHAIN is described in a new book just published by Link-Belt Co. This book shows the assembly and disassembly of this type of chain which has only three parts. The text matter is supported by tables of weights and strengths, and describes many of the uses to which chain can be put.

This chain may be used on all types of conveyors and elevators and its light weight and strength make it desirable for all long conveyors where the load is heavy and where the weight of the chain is an important consideration. The anthracite coal industry has used this chain for a number of years and has served to bring the attention of other industries to these features.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

We Are Part of All We Have Met

For hundreds of generations man has sought the finite only to find the infinite.

Wherever he pushes forward into definite knowledge, of the space around the earth, the depths of the earth and its length and breadth, discoveries reveal more distant vistas to explore.

All human knowledge, snatched from the infinite universe, becomes knowledge only through the human mind and it is the mind itself that is infinite in its possibilities.

Born with no more apparent capacity than that possessed by the infant of ten thousand years ago, the child of today catches up in a few years with the sum of human knowledge accumulated through all the intervening generations.

Even then he finds himself in a world that calls for much finer receptivity than even a generation ago to keep up with progress in any line of endeavor.

Only through multiplication of impressions has all this become possible.

Increasing the intensity, frequency and force of the impressions obtained is the way to increase the acquisition of knowledge of the world about us.

This is the way the process of catching up with the world has been speeded up during childhood, and the way of keeping up with the world through later life.

Whatever may be said against modern methods of education it must be remembered that the higher education of our fathers ofttimes comprised no wider range of knowledge than a grade school education of today.

Out in the world there are thousands of things the modern man is cognizant of to each hundred the well-informed man of the last century knew about.

Hard study and close application are still necessary to any advance in human knowledge and always will be, but the vastly multiplied contacts with life that surround us on every side are what store knowledge, broaden judgment and stimulate the mind of the man of today to a point beyond anything that was ever possible before.

Who would bemoan the destruction of that ancient Egyptian library wherein thousands of men slowly and inaccurately copied with brush and stylus, stroke by stroke, from the greatest accumulation of books in the world of that day?

Each day the printing presses of this country turn out accurate, easily-read, adequately-illustrated records of the latest accomplishments of the world's thinkers and doers, in such volume as would literally bury that ancient library.

In that library was located that early crude engine that employed steam, to study which the few learned men of that day made perilous journeys of many months to this center of ancient learning and which was doubtless often described in those manuscripts.

One hour at a modern showing of power plant machinery, equipment and supplies would give even a child more correct and lasting impressions of mechanics than the greatest scholar could obtain at that center of learning.

This one issue of POWER PLANT ENGINEERING carries in a few days the latest survey of the realm of power to engineers throughout a territory greater than all the known civilized world of those days.

Undoubtedly the great controlling force of the world today is this power to make mental impressions. It is the power that is building cities, towns, power plants and factories and every material resource, improvement and structure of industrial and commercial life.

It builds people, for people are back of all these material things, creating them, working with them and buying their products.

People will no longer travel for months at risk of life itself to sift vast unclassified knowledge as in ancient days. Only a small proportion of the people did at that time. Nor are people likely to study painfully into your proposition by the light of a log fire nor by any other light.

Their minds are tuned to a higher intensity. Their thoughts race on at a higher frequency.

Present them with clear, clean-cut, easily-receivable, authoritative impressions, conveyed by the arrangement of words and illustrations that are scientifically tuned to the mind-frequency of the people to be impressed, and they will exert themselves to see further into a proposition, study carefully into its possibilities, and adapt it to their business, professional or social life.

Influencing or being influenced, this is the process for every man. On paper, across a desk, in the engine room or around the directors' table success is obtainable in this way.

Obviously the individual problem of growth is to keep receptive to the right impressions.

Meeting the right thoughts and methods and the best machinery and equipment is certainly of paramount importance to the power plant man. Compared with this, meeting the right people for business or social advancement fades into insignificance.

To make the thoughts and methods, the machines, equipment and supplies you meet in these pages worthy of your confidence, the whole world is searched, sifted and shaped into concise form by the most expert men obtainable in design, invention, operation and administration of the power plant field.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS.
Hercules Float Wks., Springfield, Mass.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Lavino & Co., E. J. Philadelphia.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.

ASH CONVEYING SYSTEMS.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyors Corp., Chicago, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
United Conveyors Corp., Chicago, Ill.

ASH TANKS.
United Conveyors Corp., Chicago,

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co., (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.
Flexible Steel Lacing Co., Chicago.

BELTING.
New York Belting & P'k'g. Co., New York.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Diamond Power Specialty Corp., Detroit.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N. Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J. Philadelphia.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 180

Harbison - Walker Refractories Co., Pittsburgh, Pa.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J. Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw,

BOOKS AND SCHOOLS.
Sweet's Catalogue Service, Inc., New York, N. Y.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAMSHELL.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, O.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
King Refractories Co., Inc., Buffalo.
McLeod & Henry Co., Troy, N. Y.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J. Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Akron Metallic Gasket Co., Akron, O.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.
Sherwood Mfg. Co., Buffalo, N. Y.

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.